AFRL-ML-WP-TR-2001-4006

FIDEP2 USER MANUAL TO
MICROMECHANICAL MODELS FOR
THERMOVISCOPLASTIC BEHAVIOR OF METAL
MATRIX COMPOSITES

DEMIRKAN COKER
FRANK BOLLER
JOSEPH KROUPA
NOEL E. ASHBAUGH

UNIVERSITY OF DAYTON RESEARCH INSTITUTE
300 COLLEGE PARK
DAYTON, OH 45469-0128

SEPTEMBER 1998

FINAL REPORT FOR PERIOD 01 SEPTEMBER 1994 – 30 SEPTEMBER 1998

Approved for public release; distribution unlimited.

MATERIALS AND MANUFACTURING DIRECTORATE
AIR FORCE RESEARCH LABORATORY
AIR FORCE MATERIEL COMMAND
WRIGHT-PATTERSON AIR FORCE BASE, OH 45433-7750

Report Documentation Page

Report Date	Report Type	Dates Covered (from... to)
Sep 1998	N/A	-

Title and Subtitle FIDEP2 User Manual to Micromechanical Models for Thermoviscoplastic Behavior of Metal Matrix Composites	**Contract Number**
	Grant Number
	Program Element Number
Author(s)	**Project Number**
	Task Number
	Work Unit Number
Performing Organization Name(s) and Address(es) University of Dayton Research Institute 300 College Park Dayton, OH 45469-0128	**Performing Organization Report Number**
Sponsoring/Monitoring Agency Name(s) and Address(es) Materials and Manufacturing Directorate Air Force Research Laboratory Air Force Materiel Command Wright-Patterson AFB, OH 45433-7750	**Sponsor/Monitor's Acronym(s)**
	Sponsor/Monitor's Report Number(s) AFRL-ML-WP-TR-2001-4006

Distribution/Availability Statement
Approved for public release, distribution unlimited

Supplementary Notes
The original document contains color images.

Abstract
The FIDEP2 (Finite-Difference code for Elastic-viscoplastic analysis) is a PC-compatible, user-friendly computer code developed in-house at the Materials Directorate, Air Force Research Laboratory, Wright-Patterson AFB, Ohio. The program is capable of predicting micromechanical stresses in metal matrix composites under complex thermal and mechanical loading histories. The FIDEP2 is a generalized version of the FIDEP program, which was limited by the concentric cylindrical geometry and elastic-plastic constitutive model. The FIDEP2 program incorporates different loading histories, micromechanical models, and constitutive models in a modular form to allow for easy implementation of new requirements. Operation of the FIDEP2 program is straightforward, requiring a loading history file and a material properties data file. Input data are in free format, and some descriptive titles are allowed.

Subject Terms

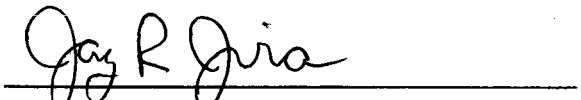
Report Classification unclassified	**Classification of this page** unclassified
Classification of Abstract unclassified	**Limitation of Abstract** UU
Number of Pages 246	

NOTICE

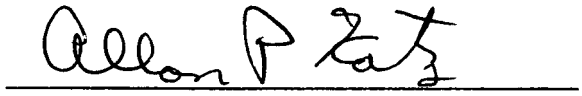
USING GOVERNMENT DRAWINGS, SPECIFICATIONS, OR OTHER DATA INCLUDED IN THIS DOCUMENT FOR ANY PURPOSE OTHER THAN GOVERNMENT PROCUREMENT DOES NOT IN ANY WAY OBLIGATE THE US GOVERNMENT. THE FACT THAT THE GOVERNMENT FORMULATED OR SUPPLIED THE DRAWINGS, SPECIFICATIONS, OR OTHER DATA DOES NOT LICENSE THE HOLDER OR ANY OTHER PERSON OR CORPORATION; OR CONVEY ANY RIGHTS OR PERMISSION TO MANUFACTURE, USE, OR SELL ANY PATENTED INVENTION THAT MAY RELATE TO THEM.

THIS REPORT IS RELEASABLE TO THE NATIONAL TECHNICAL INFORMATION SERVICE (NTIS). AT NTIS, IT WILL BE AVAILABLE TO THE GENERAL PUBLIC, INCLUDING FOREIGN NATIONS.

THIS TECHNICAL REPORT HAS BEEN REVIEWED AND IS APPROVED FOR PUBLICATION.



JAY R. JIRA, Project Engineer
Ceramics, Development & Materials
Behavior Branch
Metals, Ceramics & NDE Division



ALLAN P. KATZ, Chief
Ceramics, Development & Materials
Behavior Branch
Metals, Ceramics & NDE Division

GERALD J. PETRAK, Asst. Chief
Metals, Ceramics, and Nondestructive
Evaluation Division
Materials and Manufacturing Directorate

Do not return copies of this report unless contractual obligations or notice on a specific document requires its return.

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 074-0188

1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	SEPTEMBER 1998	Final, 09/01/1994 – 09/30/1998

4. TITLE AND SUBTITLE

FIDEP2 USER MANUAL TO MICROMECHANICAL MODELS FOR THERMOVISCOPLASTIC BEHAVIOR OF METAL MATRIX COMPOSITES

5. FUNDING NUMBERS

C: F33615-98-C-5214
PE: 62102F
PN: 4347
TA: 52
WU: 01

6. AUTHOR(S)

DEMIRKAN COKER, FRANK BOLLER, JOSEPH KROUPA, AND NOEL E. ASHBAUGH

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

UNIVERSITY OF DAYTON RESEARCH INSTITUTE
300 COLLEGE PARK
DAYTON, OH 45469-0128

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)

MATERIALS AND MANUFACTURING DIRECTORATE
AIR FORCE RESEARCH LABORATORY
AIR FORCE MATERIEL COMMAND
WRIGHT-PATTERSON AIR FORCE BASE, OH 45433-7750
POC: Jay Jira, AFRL/MLLMN, (937) 255-1358

10. SPONSORING / MONITORING AGENCY REPORT NUMBER

AFRL-ML-WP-TR-2001-4006

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION / AVAILABILITY STATEMENT

Approved for public release; distribution unlimited.

12b. DISTRIBUTION CODE

13. ABSTRACT ***(Maximum 200 Words)***

The FIDEP2 (Finite-Difference code for Elastic-viscoplastic analysis) is a PC-compatible, user-friendly computer code developed in-house at the Materials Directorate, Air Force Research Laboratory, Wright-Patterson AFB, Ohio. The program is capable of predicting micromechanical stresses in metal matrix composites under complex thermal and mechanical loading histories. The FIDEP2 is a generalized version of the FIDEP program, which was limited by the concentric cylindrical geometry and elastic-plastic constitutive model. The FIDEP2 program incorporates different loading histories, micromechanical models, and constitutive models in a modular form to allow for easy implementation of new requirements. Operation of the FIDEP2 program is straightforward, requiring a loading history file and a material properties data file. Input data are in free format, and some descriptive titles are allowed.

14. SUBJECT TERMS

Micromechanical models, FIDEP, Thermoviscoplastic behavior, Metal matrix composites, Bodner-Partom, Concentric cylinder model

15. NUMBER OF PAGES

250

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	SAR

NSN 7540-01-280-5500

Standard Form 298 (Rev. 2-89)
Prescribed by ANSI Std. Z39-18
298-102

TABLE OF CONTENTS

SECTION PAGE

LIST OF FIGURES v
LIST OF TABLES vii
FOREWORD viii

1 INTRODUCTION 1

1.1 Background 1
1.2 Program Overview 4

2 PROGRAM OPERATION 5

2.1 Input Files 5
2.1.1 Material Properties Database File 5
2.1.2 Input Loading File 11
2.2 Running the Program and Output Files 13

3 DEMONSTRATION PROBLEMS 17

3.1 Tensile Behavior of a Uniaxial Bar Using Bodner-Partom with Backstress (Cases 1 and 2) 21
3.2 Tensile Behavior of a Uniaxial Bar Using Bodner-Partom with Directional Hardening (Cases 3 and 4) 23
3.3 Uniaxial Bar under Thermal and Mechanical Loading (Case 5) 25
3.4 Cool-Down of a CCM with Elastic-Plastic Matrix (Case 6) 27
3.5 Cool-Down of a CCM Using Bodner-Partom with Directional Hardening Matrix (Case 7) 30
3.6 Thermomechanical Cyclic Behavior of CCM under Mechanical Strain Loading (Case 8) 33
3.7 Thermomechanical Cyclic Behavior of CCM under Mechanical Stress Loading (Case 9) 36
3.8 Uniaxial Bar Using Bodner-Partom with Damage Model 39
3.8.1 Loading/Unloading Behavior at 23°C (Case 10) 39
3.8.2 Loading/Unloading Behavior at 650°C (Case 11) 41
3.8.3 Full Reverse Cyclic Behavior (Case 12) 42

4 VERIFICATION OF SELECT PROBLEMS 44

4.1 Tensile Behavior of a Uniaxiial Bar Using Bodner-Partom with Backstress 44
4.2 Uniaxial Bar under Thermal and Mechanical Loading 45
4.3 Cool-Down of a CCM - Elastic-Plastic Matrix 45
4.4 Cool-Down of a CCM Using Bodner-Partom with Directional Hardening Matrix 48
4.5 Uniaxial Bar Using Bodner-Partom with Damage Model 50
4.6 Summary of Verification Cases 51

5 PROGRAM DESCRIPTION 52

5.1 General Outline of Fidep2 52
5.2 Subroutine for Constitutive Models 53
5.3 Pseudocode 54
5.4 Node Assignment in the CCM 54

6 THEORETICAL BACKGROUND 64

6.1 Micromechanical Models 64
6.1.1 Concentric Cylinder Model 64
6.1.1.1 Governing Equations 65
6.1.1.2 Computation of Axial Strain 66
6.1.1.3 Numerical Solution 68
6.1.2 Hybrid [0/90] Model 72
6.1.3 Uniaxial Stress Model 73

6.2 Constitutive Models 73
6.2.1 General Formulation 74
6.2.2 Bilinear Elastic-Plastic Model 75
6.2.3 Bodner-Partom Model with Backstress 77
6.2.4 Bodner-Partom Model with Directional Hardening 78
6.2.5 Bodner-Partom Model with Directional Hardening and Damage 79

6.3 Numerical Integration 79

REFERENCES 81

APPENDIX A Material Database File: MATERIAL.DAT 83
APPENDIX B Material Properties Database File: TIMETAL.DAT 96
APPENDIX C Output Files for Demonstration Runs 114
APPENDIX D Listing of FIDEP2 Source Code 171

LIST OF FIGURES

FIGURE		PAGE
1.	Micromechanical Models Implemented into FIDEP2	3
2.	Loading History for Tensile Loading of a Bar in Cases 1-4	21
3.	Stress-Strain Behavior for Cases 1 and 2	23
4.	Stress-Strain Behavior for Cases 3 and 4	25
5.	Loading History for Case 5	26
6.	Stress-Strain Behavior for Case 5	27
7.	Loading History for Cases 6 and 7	28
8.	Average Stresses in the Matrix and Fiber During Cool-Down	29
9.	Stresses in the Matrix at the Fiber/Matrix Interface	29
10.	Stresses Across the Cross Section at Room Temperature	30
11.	Average Stresses in the Matrix and Fiber During Cool-Down	31
12.	Stresses in the Matrix at the Fiber/Matrix Interface	32
13.	Stresses Across the Cross Section at Room Temperature	32
14.	Loading History for Case 8	33
15.	Average Stresses in the Matrix and Fiber	35
16.	Stresses Across the Cross Section at 150°C	35
17.	Loading History for Case 9	36
18.	Average Stresses in the Matrix and Fiber	38
19.	Stresses Across the Cross Section at 150°C	38
20.	Loading History for Case 10	39
21.	Stress-Strain Behavior for Case 10 (23°C)	40
22.	Loading History for Case 11	41
23.	Stress-Strain Behavior for Case 11 (650°C)	42
24.	Loading History for Case 12	42
25.	Stress-Strain Behavior for Case 12 (650°C)	43
26.	Tensile Behavior of the Bodner-Partom Model with Backstress at 25°C	44
27.	Comparison of FIDEP2 and Mathematica Solutions for Tensile Behavior of the Bodner-Partom Model with Directional Hardening	45
28.	Matrix Stress at Fiber/Matrix Interface Comparison Between FIDEP2 and the Finite Element Method with Elastic-Plastic Matrix Response	46
29.	Comparison of Stress Components at Room Temperature from Cool-Down of a Concentric Cylinder Model with Elastic-Plastic Matrix	47
30.	Matrix Stress at Fiber/Matrix Interface Comparison Between FIDEP2 and the FEM with Viscoplastic Matrix Response	48
31.	Comparison of Stress Components at Room Temperature from Cool-Down of a CCM with Viscoplastic Matrix	49
32.	Stress-strain Response of [90] Laminate Damage Model at 650°C	50
33.	Solution Deviation of Stress Response from FIDEP2 and C-Program Output	51

34. Representative Volume Element (RVE) of a Unidirectional Composite Modeled as Concentric Cylinders 65
35. Discretization of the CCM 68
36. The Linear System of Equations Resulting from the Finite Differences Formulation of the Concentric Cylinder Model 71
37. [0/90] Laminate and Its Representation as a CCM with a Parallel [90] Element 72

LIST OF TABLES

TABLE **PAGE**

1. Types of Material Models in FIDEP2 5
2. Listing of the Material Properties for ITYPE = 1 Thermoelastic Material Model 7
3. Listing of the Material Properties for ITYPE = 2, 3 Thermoelastic-Plastic Material Model 7
4. Listing of the Material Properties for ITYPE = 4 Bodner-Partom with Directional Hardening And Damage 8
5. Listing of the Material Properties for ITYPE = 5 Bodner-Partom Material Model with Backstress 9
6. Listing of the Material Properties for ITYPE = 6 Bodner-Partom Material Model with Directional Hardening Material Properties 9
7. Listing of the Material Properties for ITYPE = 7 New Bodner-Partom Model with Directional Hardening 10
8. Types of Micromechanical Models and Loading in FIDEP2 12
9. Example Loading File 13
10. Listing of Columns in Output File for Uniaxial Stress Model 14
11. Listing of Columns in First Output File for Options with CCM 15
12. Listing of Columns in Second Output File for Options with CCM 16
13. List of Material Constitutive Models in Sample Input File 17
14. Sample Material Data File 18
15. Input File for Case 1 (23° C) 22
16. Input File for Case 2 (450° C) 22
17. Input File for Case 3 (23° C) 24
18. Input File for Case 4 (650° C) 24
19. Input File for Case 5 26
20. Input File for Case 6 28
21. Input File for Case 7 31
22. Input File for Case 8 34
23. Input File for Case 9 37
24. Input File for Case 10 40
25. Input File for Case 11 41
26. Input File for Case 12 43
27. Pseudocode for FIDEP2 55
28. Pseudocode for the Subroutines in FIDEP2 57

FOREWORD

The development of this user manual was performed at the Ceramics Development and Materials Behavior Branch, Metals, Ceramics, and NDE Division, Materials and Manufacturing Directorate, Air Force Research Laboratory (AFRL/MLLN) under contract Nos. F33615-94-C-5200 and F33615-98-C-5214/ These contracts are administered under the direction of Mr. Jay R. Jira. The writing of this manual was performed by the Advanced Materials Group of the Structural Integrity Division, University of Dayton Research Institute.

SECTION 1
INTRODUCTION

FIDEP2 (**FI**nite-**D**ifference code for **E**lastic-visco**P**lastic analysis) is a PC-compatible, user-friendly computer code developed in-house at the Materials Directorate, Wright Laboratory, Wright-Patterson AFB, Ohio. The program is capable of predicting micromechanical stresses in metal matrix composites under complex thermal and mechanical loading histories. FIDEP2 is a generalized version of FIDEP program [Coker and Ashbaugh, 1992] which was limited by the concentric cylindrical geometry and elastic-plastic constitutive model. The program FIDEP2 incorporates different loading histories, micromechanical models, and constitutive models in a modular form to allow for easy implementation of new requirements.

The features of the current program include:

- Micromechanical models
  - Concentric cylinder model (CCM)
  - Hybrid CCM: a CCM with a parallel [90] element
  - Uniaxial parallel bars
- Constitutive Models
  - Elastic
  - Bilinear elastic-plastic
  - Bodner-Partom with backstress
  - Bodner-Partom with directional hardening
  - Bodner-Partom with directional hardening and damage
  - New Bodner-Partom with directional hardening
- Load histories
  - Monotonic loading
  - Isothermal fatigue
  - Thermal loading
  - Thermomechanical fatigue
- Types of load control
  - Strain
  - Stress
- Predictive Capabilities
  - Effective composite stress-strain response
  - Constituent stress-strain response

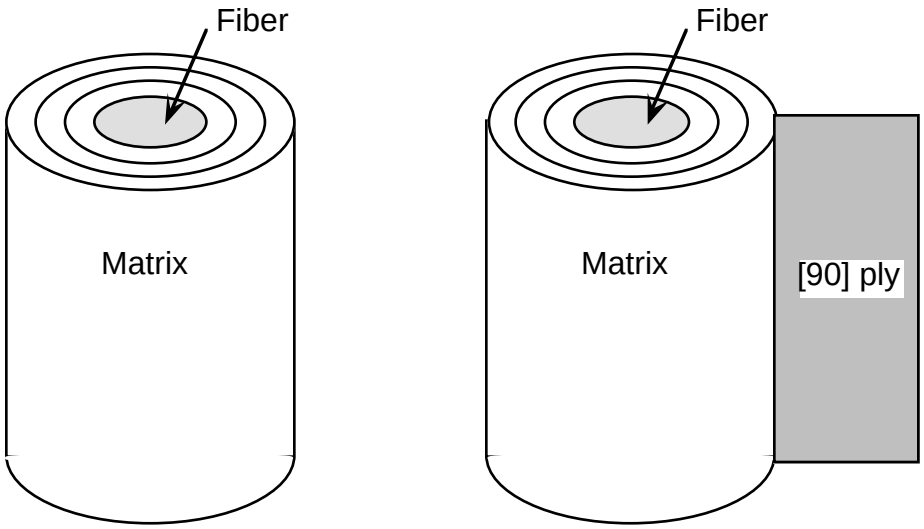
1.1 Background

The behavior of a unidirectional composite material can be determined using the CCM or the uniaxial stress model. The CCM has been shown to predict the stress distributions accurately around the fiber [Coker et al., 1993a & 1993b] whereas the uniaxial stress model can be

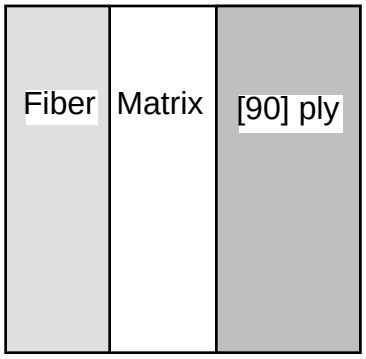
preferred for a speedy and, in some instances, accurate determination of the overall composite behavior. The behavior of a [0/90] cross-ply laminate can be determined using the CCM with smeared [90] ply properties where the strain compatibility in the load direction is preserved between the [0] ply and [90] ply. In this instance, the properties of the [90] ply are determined using finite element analysis or from experiments. The unaxial stress model can also be used to determine the overall behavior of [0/90] composite using isothermal properties to represent the [90] ply. Schematics of the three geometric models are shown in Figure 1.

A number of constitutive models can be used to characterize the constitutive behavior in micromechanical models. For the SCS-6 fiber in titanium matrix composites used in our investigations, the fiber has been characterized with a linear elastic model. The titanium matrix was Timetal¤21S and has been characterized using elastic-plastic model and elastic- viscoplastic models with Bodner-Partom formulations [Bodner and Partom, 1975]. The [90] ply has been characterized using the Bodner-Partom model with the addition of damage to account for fiber/matrix separation [Neu et al., 1996].

The major assumptions in all the micromechanical models implemented in the program were as follows: a) no spatial temperature gradients in the composite, b) perfect bonding between fiber and matrix in the [0] ply, c) generalized plane strain state, d) small displacements, and e) isotropic material properties.



(a) (b)



(c)

Figure 1. Micromechanical Models Implemented into FIDEP2 (a) CCM, (b) CCM with a Parallel [90] Ply, (c) Uniaxial Stress Model.

1.2 Program Overview

Operation of the FIDEP2 program is straightforward, requiring a loading history file and a material properties data file. Input data are in free format and some descriptive titles are allowed. The following sections describe the program in more detail. In Section 2 the FIDEP2 program operation is described in sufficient detail to allow the reader to begin to use the program. Demonstration problems are discussed in Section 3 to provide the user with examples of input and output information. Verification problems are presented in Section 4 to evaluate the accuracy of the numerical algorithms. In Section 5, a more detailed description of FIDEP2 is provided so that a more advanced user can make substantial modifications to the material and loading data files. Finally, the micromechanical models, the available constitutive models, and the numerical integration schemes which are implemented in the FIDEP2 code are summarized in Section 6.

SECTION 2
PROGRAM OPERATION

The FIDEP2 program can be run interactively on any machine with a FORTRAN compiler. Two input files are required to run the program: a material database file and a problem file. The material database consists of a compilation of the mechanical properties for the materials of interest. The problem file defines the materials to be used, the applied thermal and mechanical loading history, the volume fraction of each constituent in the composite, the type of analysis, and the parameters for requested output.

2.1 Input Files

Two input data files are required for this program: the material properties database file and the loading file.

2.1.1 Material Properties Database File

The temperature-dependent mechanical properties and coefficient of thermal expansion (CTE) for the materials of interest are collected in this database. The material model is defined by the variable ITYPE. The available material models and the corresponding ITYPE are listed in Table 1. The properties for each material are divided into the elastic part and the inelastic part. For each material, the elastic part is tabulated as a function of temperature. The elastic properties consist of the elastic modulus, Poisson's ratio and the secant CTE.

Table 1. Types of Material Models in FIDEP2

ITYPE	MATERIAL MODEL
1	Thermoelastic
2	Bilinear thermoelastic-plastic - Algorithm 1
3	Bilinear thermoelastic-plastic - Algorithm 2
4	Bodner-Partom with directional hardening and damage
5	Bodner-Partom with backstress
6	Bodner-Partom with directional hardening
7	New Bodner-Partom with directional hardening

The material database file format is as follows:

The top line in the file

1 line	title

For each material, the format for the elastic part is as follows:

1 line	separating or dummy line between materials
1 line	IMAT, material number in sequential order;
	ITYPE, type of material model

1 line	name of material
1 line	NROW, number of rows of data
1 line	header line for the properties
NROW lines	Temperature, elastic modulus (GPa);
	Poisson's ratio, secant CTE (10-6/° C)
1 line	Reference temperature ° C for secant CTE

If the material is elastic, i.e., ITYPE=1, the properties for the next material are listed. If the material is inelastic, i. e., ITYPE›1, the elastic part is followed by tables of the inelastic properties. The specific order of listing of the properties for different constitutive models is shown in Table 2. The inelastic properties for these constitutive models should be listed in the exact sequence defined in this table. The temperature-dependent properties can be separated into different sets to accommodate the properties measured at different temperature intervals from each other. Each set is formatted as follows:

1 line	NSET, number of sets of inelastic properties
1 line	NROW, number of rows of data;
	N, (umber of columns of properties
1 line	header line
NROW lines	Temperature; property 1; property 2; ... ; property N
	(If NROW = 1, then no temperature is specified)

Table 2. Listing of the Material Properties for ITYPE = 1 Thermoelastic Material Model

TP(IM, IR, IC)	IC	IS
E(IR)	1	
_(IR)	2	1 = elastic properties
CTE(IR)	3	

Table 3. Listing of the Material Properties for ITYPE = 2, 3 Thermoelastic-Plastic Material Model

TP(IM, IR, IC)	IC	IS
E(IR)	1	
_(IR)	2	1 = elastic properties
CTE(IR)	3	
s_y(IR)	4	2 = First set of inelastic properties
E_p(IR)	5	

Table 4. Listing of the Material Properties for ITYPE = 4 Bodner-Partom with Directional Hardening And Damage

TP(IM, IR, IC)	IC	IS
E(IR)	1	
_(IR)	2	1 = elastic properties
CTE(IR)	3	
ISUB	4	
n(IR)	5	2 = First set of inelastic properties
Z_0(IR)	6	
Z_3(IR)	7	
m_2(IR)	8	
A_1	9	
m_1	10	3 = Second set of inelastic properties
Z_1	11	
r_1=r_2	12	
D_o	13	
Sm	14	4 = Damage Properties
Sch	15	
Scl	16	
m	17	
Theta	18	5 =Damage Properties
D*	19	
Beta	20	
Dch	21	

Table 5. Listing of the Material Properties for ITYPE = 5 Bodner-Partom Material Model with Backstress

TP(IM, IR, IC)	IC	IS
E(IR)	1	
_(IR)	2	1 = elastic properties
CTE(IR)	3	
ISUB	4	
n(IR)	5	
Z_o(IR)	6	2 = First set of inelastic properties
f_1(IR)	7	
f_3(IR)	8	
W_{max}(IR)	9	
s_o	10	3 = Second set of inelastic properties
D_o	11	

Table 6. Listing of the Material Properties for ITYPE = 6 Bodner-Partom Material Model with Directional Hardening

TP(IM, IR, IC)	IC	IS
E(IR)	1	
_(IR)	2	1 = elastic properties
CTE(IR)	3	
ISUB	4	
n(IR)	5	2 = First set of inelastic properties
Z_0(IR)	6	
Z_3(IR)	7	
m_2(IR)	8	
A_1	9	
m_1	10	3 = Second set of inelastic properties
Z_1	11	
r_1=r_2	12	
D_o	13	

Table 7. Listing of the Material Properties for ITYPE = 7 New Bodner-Partom Model with Directional Hardening

TP(IM, IR, IC)	IC	IS
E(IR)	1	
_(IR)	2	1 = elastic properties
CTE(IR)	3	
ISUB	4	
n(IR)	5	2 = First set of inelastic
Z_0(IR)	6	properties
Z_3(IR)	7	
m_2(IR)	8	
A_1	9	
m_1	10	3 = Second set of inelastic
Z_1	11	properties
r_1=r_2	12	
D_o	13	

Notes:

IM = Material number

IR = Row number

IS = Data set number

IC = Column number

TP(IM, IR, IC) = Temperature-dependent material properties array where IM is the material number, IR is the row number of the corresponding temperature value, and IC is the column number corresponding to the mechanical property

AT(IM, IR, IS) = Temperature values for the data set of temperature-dependent properties, IS

Material properties can also be given in function form in the program by inserting -9999 for the requested property in the table and adding the appropriate function to the program. Two material data files were used in our investigations. MATERIAL.DAT, consisting of properties for SCS-6 fiber, Ti-24Al-11Nb and Timetal¤21S matrices (see Appendix A), and TIMETAL.DAT, consisting of properties for SCS-6 fiber, Timetal21S matrix, and [90] SCS-6/Timetal21S composite (see Appendix B).

For material represented by a Bodner-Partom model, and additional material properties, ISUB, is used. The ISUB initiates more subcuts in numerical computation for higher temperatures where viscoplastic response is more prevalent. The values of ISUB are defined by the user. Examples of ISUB values are shown later in Table 8. For the material information shown in Appendices A and B, ISUB values would need to be included for appropriate material model types.

2.1.2 Input Loading File

This file consists of loading conditions, type of problem, materials to be used in the analysis, and parameters for printing the output. There are two types of case files: stress loading and strain loading. These files differ only in the loading section. The format is as follows:

1 line	Title line
1 line	ICASE, type of problem, ILOAD, loading type
1 line	Material database file name
1 line	NCBlock, number of blocks in loading history
1 line	Header line for block
1 line	NLOAD, number of rows of data in the block loading history, NCYCLE, number of cycles for block execution, IPRINTSTEP, print frequency, ISTEPOUT, print start, INTOUT, out put at material number, NIOUT, crossectional stress file
1 line	Step numbers of output of stresses at the cross section if NIOUT≠ 0
1 line	Header line for the loading history table
NLOAD lines	Step number, time (s), temperature: (for stress loading) applied axial stress (MPa); radial stress (MPa); or (for strain loading) applied axial strain (mm/mm)
	*Repeat previous 5 items for each block
1 line	blank
1 line	NOMAT, number of materials
1 line	IMAT, material ID; VF, volume fraction; NODES, number of nodes

The loading cases and the corresponding ICASE number are shown in Table 4.

Table 8. Types of Micromechanical Models and Loading in FIDEP2

ICASE	PROBLEM TYPE
1	Multiple concentric cylinder model
2	Uniaxial stress model
3	Concentric cylinder model with parallel [90] element
ILOAD	**PROBLEM TYPE**
0	Stress load control
1	Strain load control

An example loading file is shown in Table 9.

Table 9. Example Loading File

Example file	Explanation
COOL-DOWN OF [0] SCS-6/TIMETAL®21S	header line
1 0	case number and stress/strain control flag
MATERIAL	material file name
1	number of blocks in history data
BLOCK 1 NUMBER OF CYCLES PRFREQ PRSTART INOUT NIOUT	header line
5 1 100 9 1 3	number of rows of history data and output flags
3 720 900	detailed output at these steps
Step, t(s), T(C), Axial, Radial	header line
0 0 900 0 0	
1800 14400 621 0 0	
3600 43200 621 0 0	loading data
7200 72000 23 0 0	
9000 72090 900 0 0	
2	number of materials
14 0.35 3	material ID, volume fraction, number of nodes
16 0.65 15	

2.2 Running the Program and Output Files

The program is run interactively after compiling on any computer with a FORTRAN compiler. The user is prompted for input and output filenames and given the option to print out material properties in the output file.

The output consists of the echo of the input parameters and the computed stress and strain values. One output file is created for the uniaxial stress model. The top lines consist of the input loading data and material properties if requested, followed by output data with columns shown in Table 10.

Two output files are created for the models consisting of the CCM. The first file contains echo of the input loading parameters and, if desired, the material properties. For the CCM, the first output file consists of the stresses and strains at the interface for every n steps specified in the load history file as shown in Table 11. At the steps specified by the input file, stresses and plastic strains across the cross section as a function of radius are written to a separate output. The second data file, called the Y-file, includes the average stresses and mechanical strains in each material and the total composite strain, as shown in Table 12. All output files also contain the computational step number, time, temperature and the resultant composite stress.

Table 10. Listing of Columns in Output File for Uniaxial Stress Model

Column	Variable
1	Block
2	Cycle
3	Computational Step
4	Time (s)
5	Temperature (° C)
6	Applied Stress (MPa)
7	Stress in Laminate 1 (MPa)
8	Stress in Laminate 2 (MPa)
9	Stress in Laminate 3 (MPa)
10	Total Strain
11	Strain in Laminate 1
12	Strain in Laminate 2
13	Strain in Laminate 3

Table 11. Listing of Columns in First Output File for Options with CCM

Column	Variable
1	Block
2	Cycle
3	Computational Step
4	Time (s)
5	Temperature (° C)
6	Effective stress at the interface(MPa)
7	Radial stress at the interface (MPa)
8	Tangential stress at the interface (MPa)
9	Axial stress at the interface (MPa)
10	Radial strain at the interface
11	Tangential strain at the interface
12	Axial strain at the interface

* Cross sectional results at the specified computational step in the input file

1	Radius
2	Effective stress (MPa)
3	Radial stress (MPa)
4	Tangential stress (MPa)
5	Axial stress (MPa)
6	Radial strain
7	Tangential strain
8	Axial strain

Table 12. Listing of Columns in Second Output File for Options with CCM

Column	Variable
1	Block
2	Cycle
3	Computational step
4	Time (s)
5	Temperature (° C)
6	Applied stress (MPa)
7	Average fiber stress (MPa)
8	Average matrix stress (MPa)
9	Average [90] ply stress (MPa)
10	Mechanical strain in the fiber
11	Mechanical strain in the matrix
12	Mechanical strain in the [90] ply
13	Total composite strain

SECTION 3
DEMONSTRATION PROBLEMS

In this section the capabilities of the FIDEP2 code are exercised and some benchmark problems are presented. The material models used for these problems are given in Table 13. Also, references are given in the table for the sources of the material properties in the unified model. The material data file for these runs is listed in Table 14. The file consists of the material properties for Timetal¤21S matrix, SCS-6 fiber, and material constants for the [90] SCS-6/Timetal21S damage model.

The cases that are investigated are monotonic loading of a uniaxial bar, cool-down of a concentric cylinder model, thermomechanical fatigue behavior of a concentric cylinder model, and cyclic behavior of a [90] ply composite using a damage model. The input file, a plot of the loading history and relevant output plots are presented. The complete output files are listed in Appendix C. In running problems, if a convergence is not obtained, the number of computational steps can be increased until the solution converges. For time-independent problems, the usual number of computational steps between loading peaks is 30 steps; for time-dependent constitutive models, the steps are approximately 400.

Table 13. List of Material Constitutive Models in Sample Input File

Material No.	Material Model	Material Definition
1	1	Thermoelastic response for SCS-6 fiber
2	2	Bilinear elastic-plastic response for Timetal21S
3	5	Bodner-Partom theory with backstress for Timetal21S (Sherwood and Quimby, 1995)
4	6	Bodner-Partom theory with directional hardening for Timetal21S (Neu, 1993)
5	4	Directional B-P theory with [90] ply damage model (Neu et al., 1996)

Table 14. Sample Material Data File

```
Sample Material Database File for FIDEP2.6
 =====================================================
 1   1
   Thermo-Elastic Response for SCS-6 fiber
 10
     T(C)         E(GPa)        NU         CTE(1E-6/C)
      21.11        393         0.25        3.9907
      93.33        390         0.25        4.0289
     204.44        386         0.25        4.0989
     315.56        382         0.25        4.1801
     426.67        378         0.25        4.2655
     537.78        374         0.25        4.3510
     648.89        370         0.25        4.4324
     760.00        365         0.25        4.5074
     871.11        361         0.25        4.5718
     1093.3        354         0.25        4.5723
 900
-------------------------------------------------------
 2   2
   Bilinear Elastic-Plastic Response for Timetal21S
 7
     T(C)          E(GPa)          NU        CTE(1E-6/C)
     23             114          0.34        8.8700
     260            114          0.34        9.8800
     482             90          0.34       10.713
     650             78          0.34       11.282
     760             70          0.34       11.624
     815             64          0.34       11.787
     900             55          0.34       12.027
 900
 1
 7 2
     T(C)          SY(MPa)       EP(GPa)
     23             1107.         0.459
     260            1010.         1.486
     482             810.         2.000
     650             350.         0.000
     760             120.         0.000
     815             110.         0.000
     900             94.0         0.000
-------------------------------------------------------
3   5
   Sherwood's Model with Backstress for Timetal21S
17
    Temp          E (GPa)         NU         CTE (1E-6/C)
    23.0          114.30       0.3400        9.490
   260.0          108.00       0.3400        10.45
   482.0           90.37       0.3400        11.24
   560.0           83.02       0.3400        11.50
   584.0           80.76       0.3400        11.57
   600.0           79.25       0.3400        11.62
   610.0           78.31       0.3400        11.66
   620.0           77.37       0.3400        11.69
   627.0           76.71       0.3400        11.71
   634.0           76.05       0.3400        11.73
   639.0           75.58       0.3400        11.75
   643.0           75.20       0.3400        11.76
   647.0           74.82       0.3400        11.78
   650.0           74.54       0.3400        11.78
   760.0           60.28       0.3400        12.11
   815.1           53.22       0.3400        12.27
   900.0           53.22       0.3400        12.27
```

Table 14. Sample Material Data File (Continued)

```
   900.0
2
 17  6
    Temp  ISUB      n      Zo           F1          F3         BSMAX
   22.99    1.   1.9500   3.390E+02   4.499E+04   8.795E-01  7.440E+02
   260.0    2.   1.8500   3.820E+02   3.700E+04   8.152E-01  5.730E+02
   482.0    2.   1.5000   4.980E+02   3.559E+04   7.954E-01  5.120E+02
   560.0    2.   0.8500   1.565E+03   2.858E+04   4.746E-01  3.000E+02
   584.0    5.   0.6500   3.173E+03   2.643E+04   3.759E-01  2.350E+02
   600.0   10.   0.5170   6.684E+03   2.499E+04   3.101E-01  1.910E+02
   610.0   15.   0.4330   1.326E+04   2.409E+04   2.690E-01  1.640E+02
   620.0   20.   0.3500   3.597E+04   2.319E+04   2.279E-01  1.360E+02
   627.0   20.   0.2920   1.007E+05   2.257E+04   1.991E-01  1.180E+02
   634.0   20.   0.2330   4.681E+05   2.194E+04   1.703E-01  9.900E+01
   639.0   20.   0.1920   2.472E+06   2.149E+04   1.497E-01  8.500E+01
   643.0   20.   0.1580   1.752E+07   2.113E+04   1.333E-01  7.400E+01
   647.0   20.   0.1250   3.519E+08   2.077E+04   1.168E-01  6.300E+01
   650.0   20.   0.1000   1.240E+10   2.050E+04   1.045E-01  5.500E+01
   760.0   30.   0.1200   2.470E+08   9.900E+02   2.400E-03  3.000E+00
   815.1   50.   0.1160   2.450E+08   7.600E+02   1.900E-03  1.000E+00
   900.0   60.   0.0700   2.430E+08   5.000E+02   5.000E-04  5.000E-01
 1  1
   D0
  1.0E4
---------------------------------------------------------------
4   6
Bodner-Partom Theory for Timetal21S, Neu 93
 16
   T(C)        E(GPa)       NU       CTE(1E-6/C)
   23          112.0       0.34       9.7787
   260         108.0       0.34      10.713
   315         106.1       0.34      10.915
   365         104.1       0.34      11.093
   415         101.7       0.34      11.267
   465         99.09       0.34      11.436
   482         98.11       0.34      11.492
   500         97.05       0.34      11.550
   525         95.50       0.34      11.631
   550         93.87       0.34      11.710
   575         92.17       0.34      11.788
   600         90.40       0.34      11.865
   650         86.61       0.34      12.014
   760         77.22       0.34      12.323
   815         71.96       0.34      12.467
   900         63.12       0.34      12.689
   900
 2
 16  5
   T(C)   ISUB      N     Z0=Z2(1/S)     Z3(MPa)    M2(1/MPa)
    23     1.     4.800     1550.0        100.0      0.350
    260    1.     3.500     1300.0        300.0      0.350
    315    1.     3.054     1250.4        390.0      1.502
    365    1.     2.649     1205.4        500.0      2.549
    415    2.     2.243     1160.4        660.0      3.597
    465    2.     1.838     1115.3        960.0      4.644
    482    5.     1.700     1100.0        1100.      5.000
    500    7.     1.500     1089.3        1300.      5.763
    525   10.     1.280     1074.4        1670.      6.822
    550   10.     1.100     1059.5        2100.      7.881
    575   10.     0.970     1044.6        2600.      8.941
    600   15.     0.820     1029.8        3700.      10.00
    650   15.     0.740     1000.0        3800.      10.00
```

Table 14. Sample Material Data File (Continued)

```
   760   20.     0.580      600.0       4000.      15.00
   815   20.     0.550      300.0       4100.      30.00
   900   30.     0.550      300.0       4300.      30.00
1 5
   A1=A2      M1          Z1         R1=R2       DO
  -9999       0.0       1600.         3.0       10000.
-------------------------------------------------------
5     4
Directional B-P Theory with [90] Ply Damage Model of Neu 94
8
    T(C)     E(GPa)     NU     CTE(1E-6/C)
     23       133     0.19      9.7787
     260      128     0.19      10.713
     482      119     0.19      11.492
     538      115     0.18      11.670
     593      112     0.18      11.860
     650      105     0.17      12.014
     815       50     0.17      12.467
     900       20     0.17      12.689
900
4
16  5
     T(C)  isub     N     Z0=Z2(1/S)   Z3(MPa)    M2(1/MPa)
      23     1.   4.800     1550.0      100.0      0.350
     260     2.   3.500     1300.0      300.0      0.350
     315     2.   3.054     1250.4      390.0      1.502
     365     2.   2.649     1205.4      500.0      2.549
     415     3.   2.243     1160.4      660.0      3.597
     465     3.   1.838     1115.3      960.0      4.644
     482     4.   1.700     1100.0      1100.      5.000
     500     5.   1.500     1089.3      1300.      5.763
     525     7.   1.280     1074.4      1670.      6.822
     550    10.   1.100     1059.5      2100.      7.881
     575    20.   0.970     1044.6      2600.      8.941
     600    30.   0.820     1029.8      3700.      10.00
     650    40.   0.740     1000.0      3800.      10.00
     760    50.   0.580      600.0      4000.      15.00
     815    60.   0.550      300.0      4100.      30.00
     900    70.   0.550      300.0      4300.      30.00
1  5
    A1=A2       M1          Z1        R1=R2        DO
   -9999        0.0       1600.0       3.0       10000.
7 1
    Temp        Sm
     23.         190 .
     260.        130.
     482.        70.
     538.        50.
     593.        36.
     650.        17.
     815.        .0
1 7
    scho      scl       m     theta      Dstar     beta    Dch
     80        0.        1.    100.       0.61     0.05    0.5
-------------------------------------------------------
6   7
```

3.1 Tensile Behavior of a Uniaxial Bar Using Bodner-Partom with Backstress (Cases 1 and 2)

Simulation of strain controlled tensile loading were conducted on uniaxial bars at 25° C and 450° C to verify the implementation of the Bodner-Partom with backstress constitutive model in the code. The loading history, consisting of a constant temperature and a constant strain rate, is shown in Figure 2. The material is ramped to a strain of 0.04 at 23° C and 450° C at a strain rate of 833E-6/s. The input files are shown in Tables 14 and 15. The resulting stress-strain behavior is shown in Figure 3.

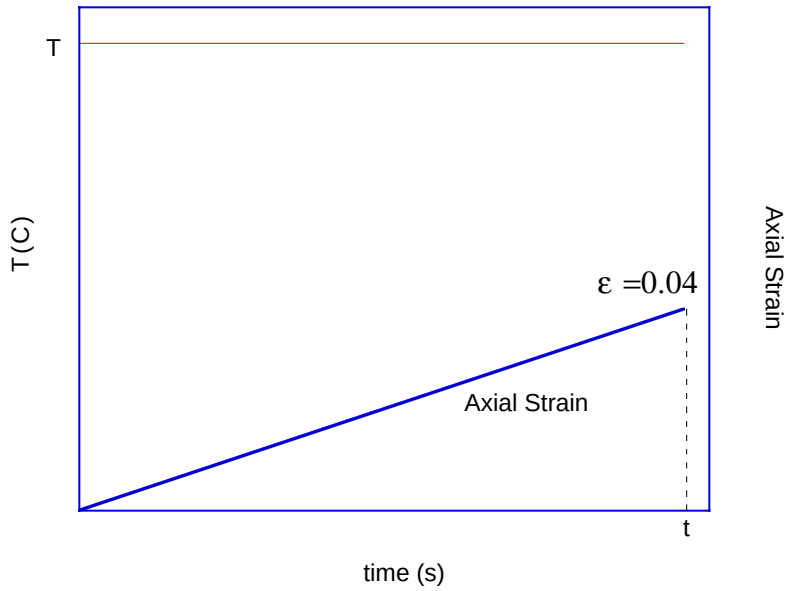


Figure 2. Loading history for Tensile Loading of a Bar in Cases 1 - 4.

Table 15. Input File for Case 1 (23° C)

```
Bodner-Partom with Backstress at 23C (strain rate = 833E-6/s)
2          1
sample_mat
1
BLOCK 1   NUMBER OF CYCLES   PRFREQ   PRSTART   INTOUT   NIOUT
          2                    1                 20       0              1                0
  Step      Time      Temp     Load      SR
     0       0.0      23.0      0.0      0.
   480      48.0      23.0     0.04      0.

1
3   1.00      2
```

Table 16. Input File for Case 2 (450° C)

```
Bodner-Partom with Backstress at 450C (strain rate = 833E-6/s)
2          1
sample_mat
1
BLOCK 1   NUMBER OF CYCLES   PRFREQ   PRSTART   INTOUT   NIOUT
          2                    1                 20       0              1                0
  Step      Time      Temp     Load      SR
     0       0.0     450.0      0.0      0.
   480      48.0     450.0     0.04      0.

1
3   1.00      2
```

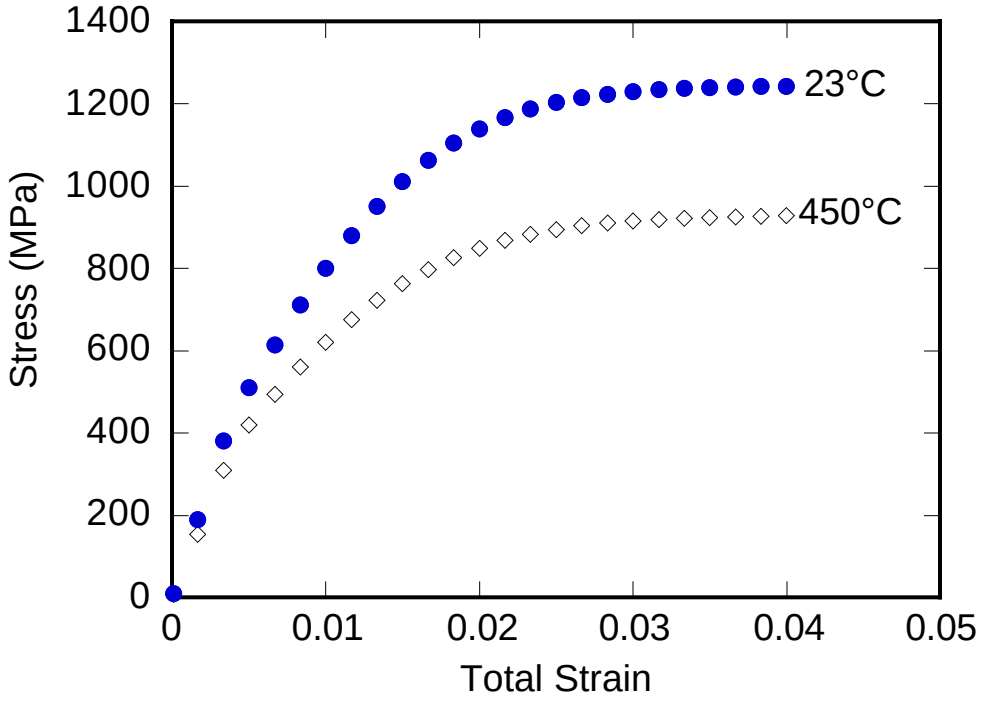


Figure 3. Stress-Strain Behavior for Cases 1 and 2.

3.2 Tensile Behavior of a Uniaxial Bar Using Bodner-Partom with Directional Hardening (Cases 3 and 4)

Simulation of strain-controlled tensile loading were conducted on uniaxial bars at 25° C and 650° C to verify the implementation of the Bodner-Partom model with directional hardening in the code. The loading history, consisting of a constant temperature and a constant strain rate, is shown in Figure 2. The material is ramped to a strain of 0.04 at 23° C and 650° C at a strain rate of 8.33E-6/s. The input files are shown in Tables 17 and 18. For case 4 at 650° C, the program did not converge for the same 480 steps used in the previous cases. The steps were increased until the program did converge, which in this case turned out to be 1,600 steps. The stress-strain behavior is shown in Figure 4.

Table 17. Input File for Case 3 (23° C)

```
Bodner Partom with Dir. Hardening at 23C (strain rate = 833E-6/s)
2          1
sample_mat
1
BLOCK 1   NUMBER OF CYCLES   PRFREQ   PRSTART   INTOUT   NIOUT
          2                    1                20       0              1                0
  Step      Time      Temp     Load      SR
     0       0.0      23.0      0.0      0.
   480    4800.0      23.0     0.04      0.

1
4   1.00      2
```

Table 18. Input File for Case 4 (650° C)

```
Bodner Partom with Dir. Hardening at 650C (strain rate = 833E-6/s)
2          1
sample_mat
1
BLOCK 1   NUMBER OF CYCLES   PRFREQ   PRSTART   INTOUT   NIOUT
          2                    1                40       0              1                0
  Step      Time      Temp     Load      SR
     0       0.0      650.0     0.0      0.
  1600    4800.0      650.0     0.04     0.

1
4   1.00      2
```

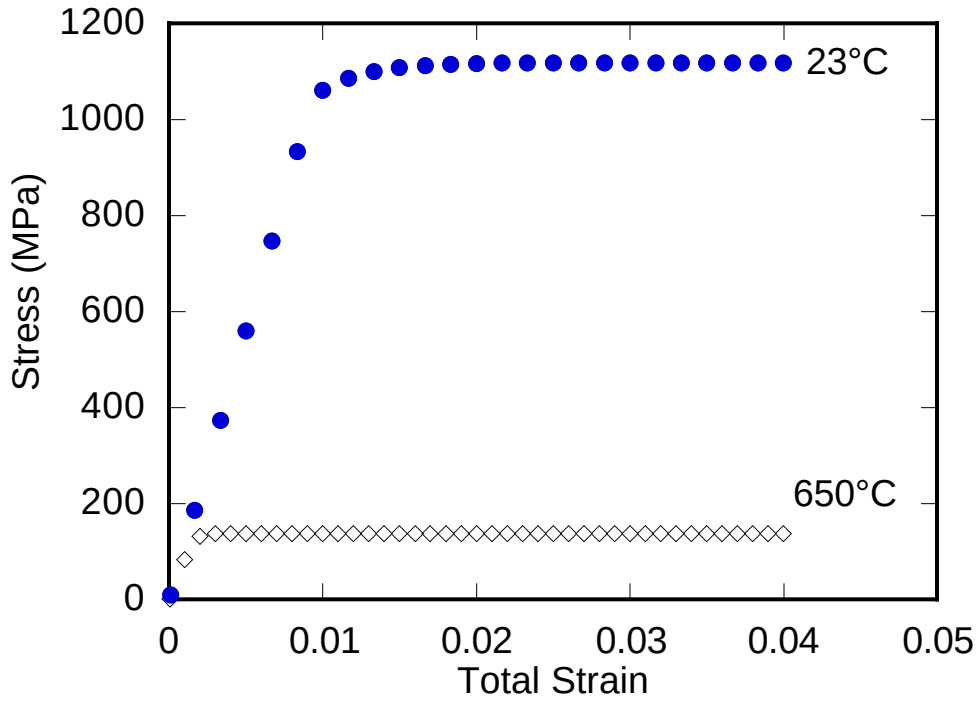


Figure 4. Stress-Strain Behavior for Cases 3 and 4.

3.3 Uniaxial Bar Under Thermal and Mechanical Loading (Case 5)

Thermomechanical strain loading was applied to a uniaxial bar with loading history as shown in Figure 5. The input file is shown in Table 19. The resultant stress-strain behavior is shown in Figure 6.

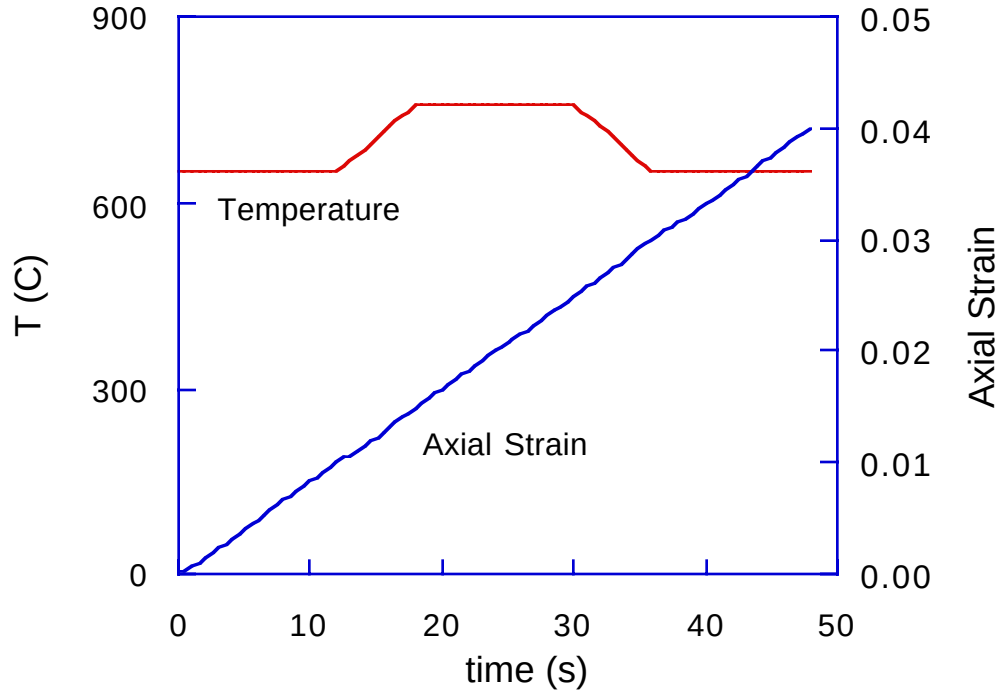


Figure 5. Loading History for Case 5.

Table 19. Input File for Case 5

```
Bodner Partom with Dir. Hardening from 650C to 750C
2          1
sample_mat
1
BLOCK 1   NUMBER OF CYCLES   PRFREQ   PRSTART   INTOUT   NIOUT
          6                  1                 40       0              1              0
  Step      Time      Temp      Load      SR
     0       0.0     650.0       0.0      0.
  1200      12.0     650.0      0.01      0.
  1800      18.0     750.0     0.015      0.
  2400      30.0     750.0     0.025      0.
  3600      36.0     650.0      0.03      0.
  4800      48.0     650.0      0.04      0.

1
4   1.00      2
```

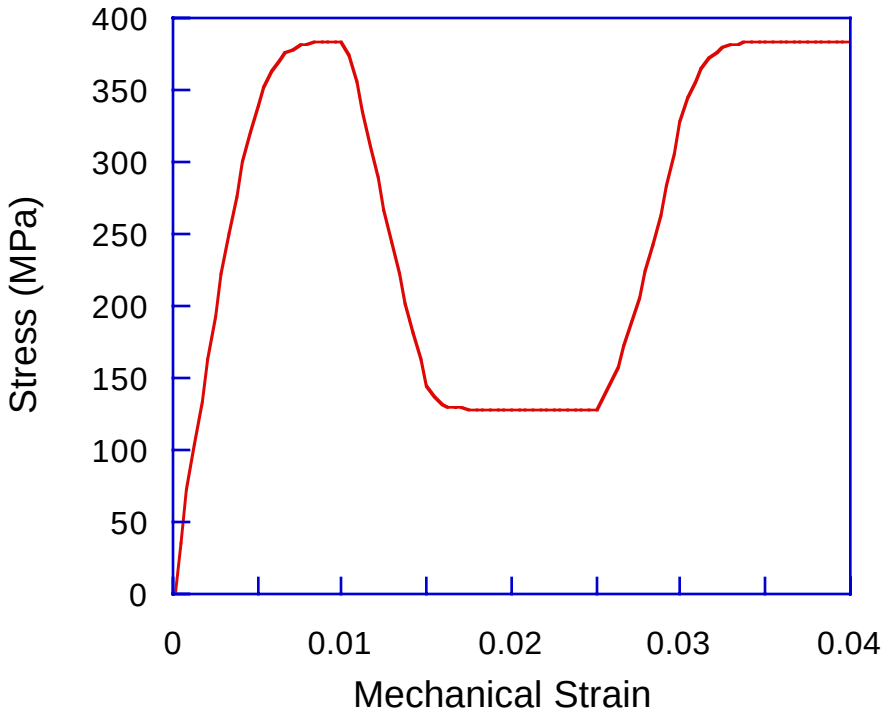


Figure 6. Stress-Strain Behavior for Case 5.

3.4 Cool-Down of a CCM with Elastic-Plastic Matrix (Case 6)

The CCM with elastic SCS-6 fiber and bilinear thermoelastic-plastic Timetal21S matrix is cooled down to room temperature from a processing temperature of 900° C. The temperatures profile is shown in Figure 7. The input file is given in Table 20. The average matrix and fiber stress obtained from the second output file is shown in Figure 8. The stress components in the matrix at the interface, which is obtained from the first output file, are shown in Figure 9. The stresses across the cross section at room temperature are shown in Figure 10, obtained from the end of the first output file.

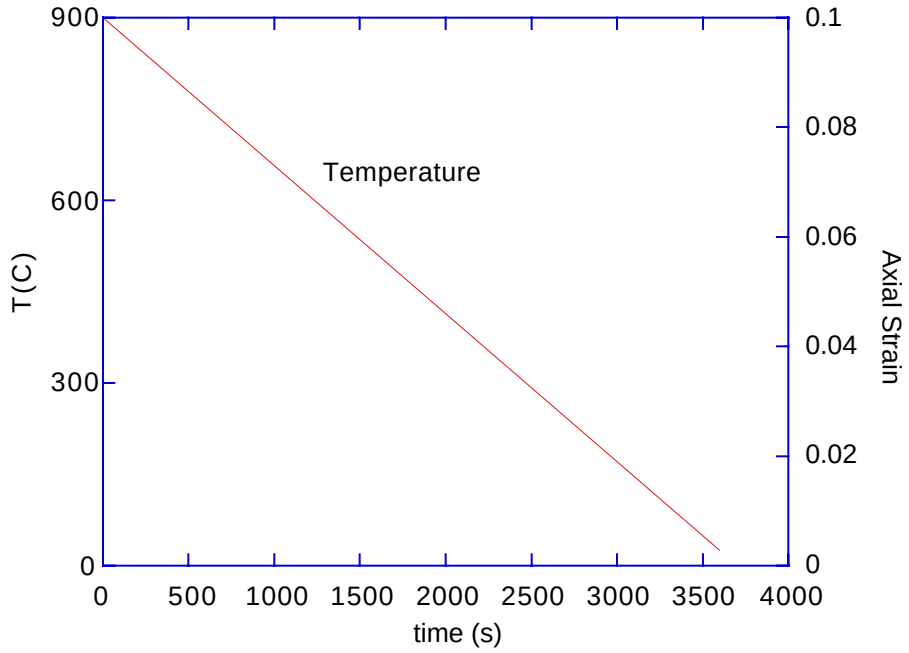


Figure 7. Loading History for Cases 6 and 7.

Table 20. Input File for Case 6

```
SCS-6/TIMETAL21S(EP) Concentric Cylinder cooled from 900C to 23C
1          0
sample_mat
1
BLOCK 1   NUMBER OF CYCLES   PRFREQ   PRSTART   INTOUT   NIOUT
          2                    1                 10       0              2              1
360
  Step      Time      Temp     Load      SR
     0       0.0     900.0      0.0      0.
   360    3600.0      23.0      0.0      0.

2
1   0.35     5
2   0.65     15
```

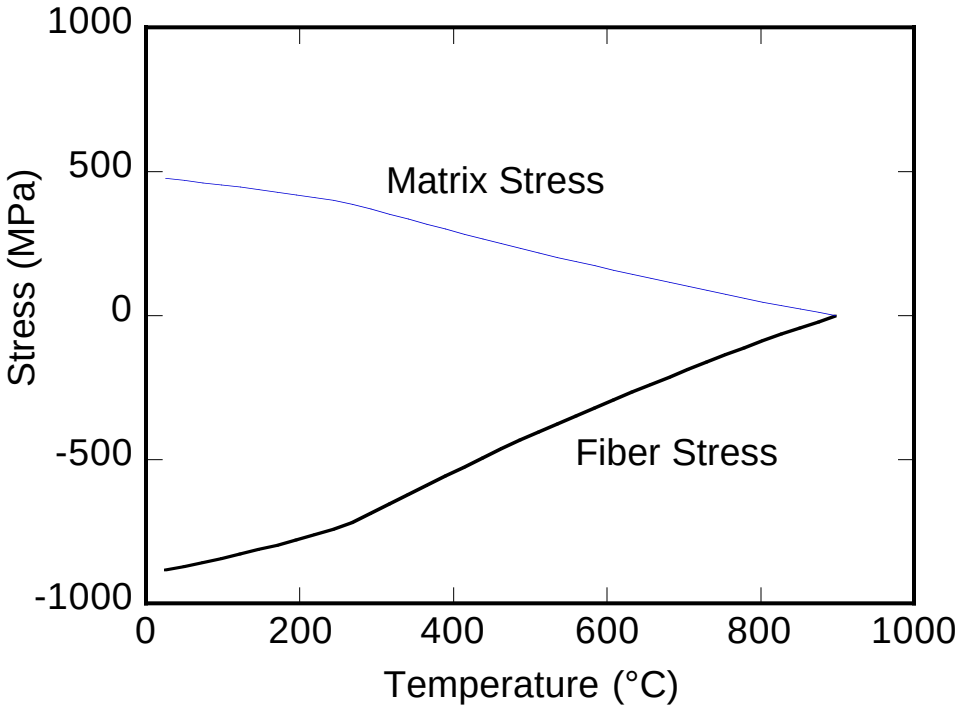


Figure 8. Average Stresses in the Matrix and Fiber During Cool-Down.

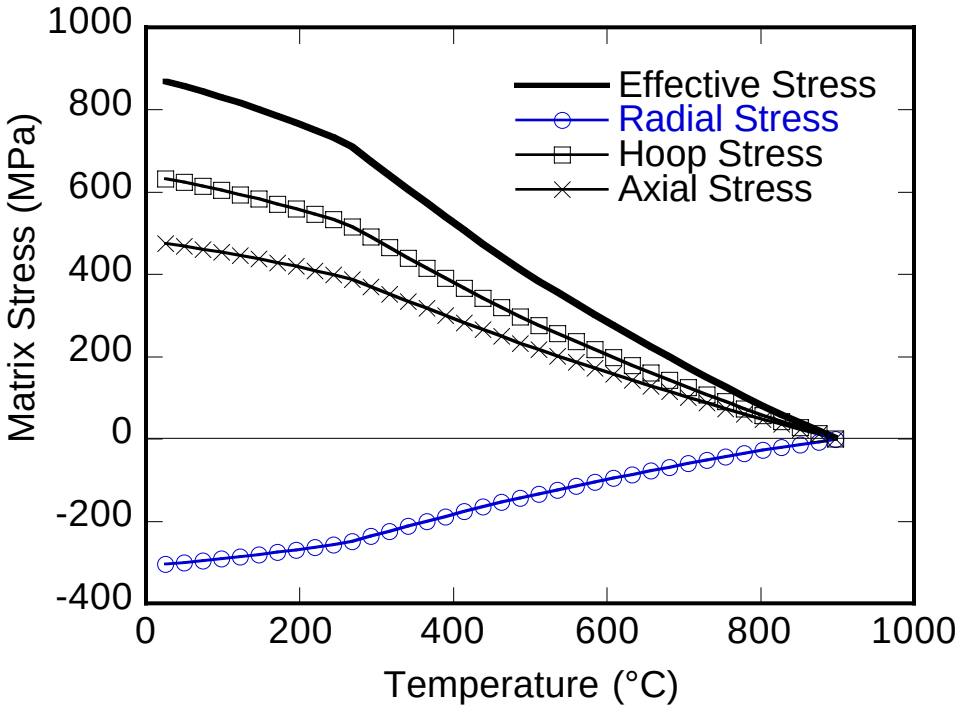


Figure 9. Stresses in the Matrix at the Fiber/Matrix Interface — Case 6.

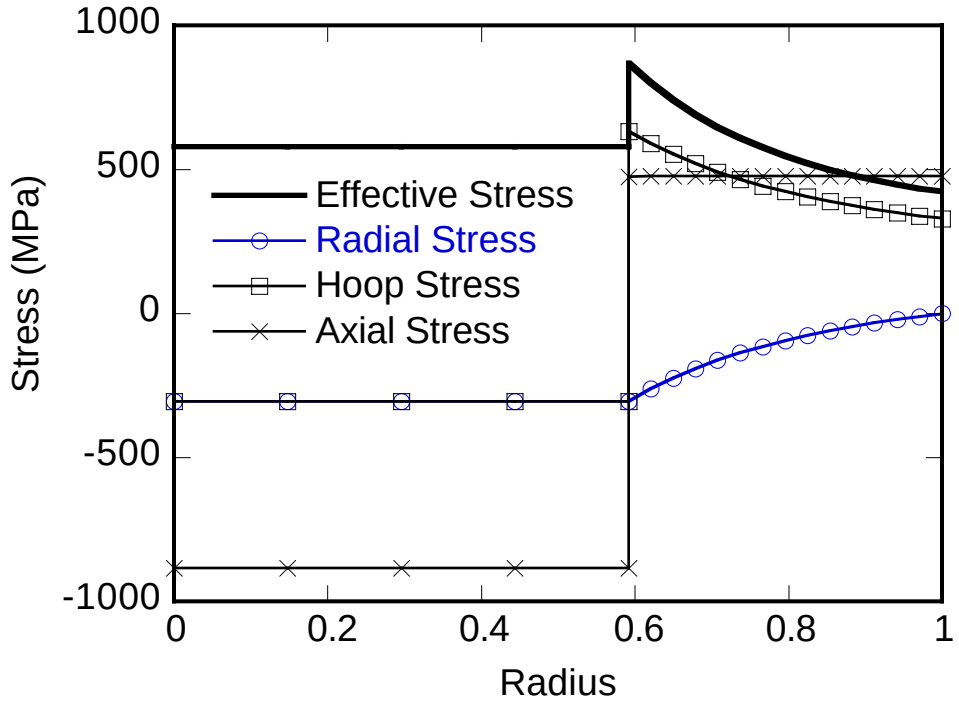


Figure 10. Stresses Across the Cross Section at Room Temperature.

3.5 Cool-Down of a CCM Using Bodner-Partom with Directional Hardening Matrix (Case 7)

The CCM with elastic SCS-6 fiber and viscoplastic Timetal21S matrix is cooled down to room temperature from a processing temperature of 900° C as is shown in Figure 5. The input file is given in Table 21. The average matrix and fiber stresses obtained from the second output file are shown in Figure 11. The stress components in the matrix at the interface are shown in Figure 12 which is obtained from the first output file. The stresses across the cross section at room temperature are shown in Figure 13, obtained from the end of the first output file. Compared to the Case 6 the stresses have relaxed due to viscoplastic behavior of the matrix.

Table 21. Input File for Case 7

```
SCS-6/TIMETAL21S(DBP) Concentric Cylinder cooled from 900C to 23C
1          0
sample_mat
1
BLOCK 1   NUMBER OF CYCLES   PRFREQ   PRSTART  INTOUT   NIOUT
          2                    1                 100       0              2                  1
3600
  Step      Time      Temp     Load      SR
     0       0.0     900.0      0.0      0.
3600    3600.0      23.0       0.0      0.

2
1   0.35     7
2   0.65     20
```

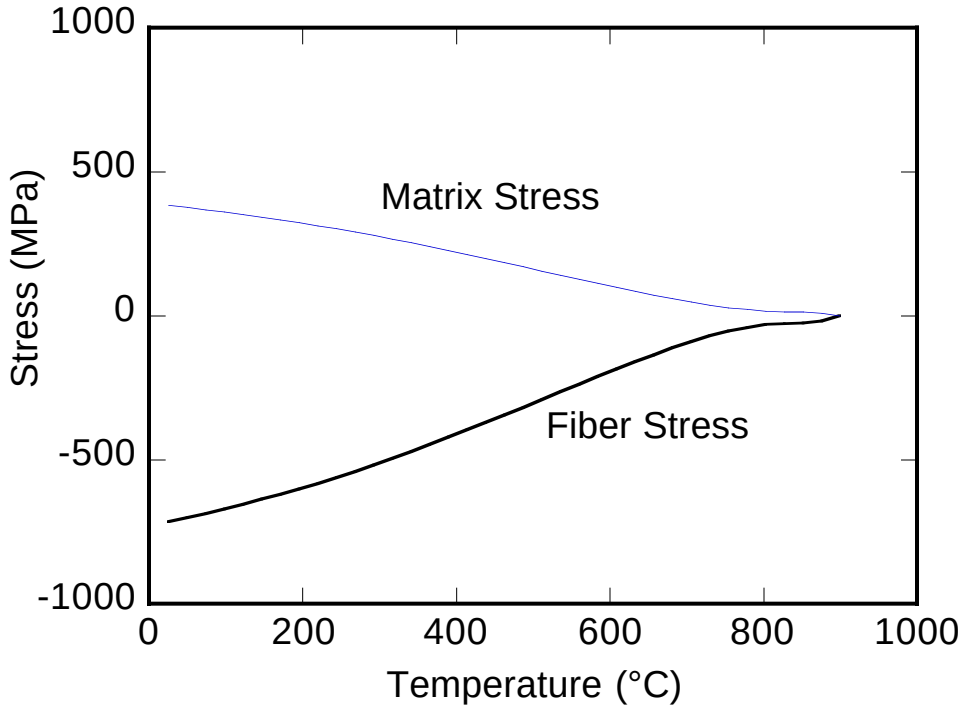


Figure 11. Average Stresses in the Matrix and Fiber During Cool-Down.

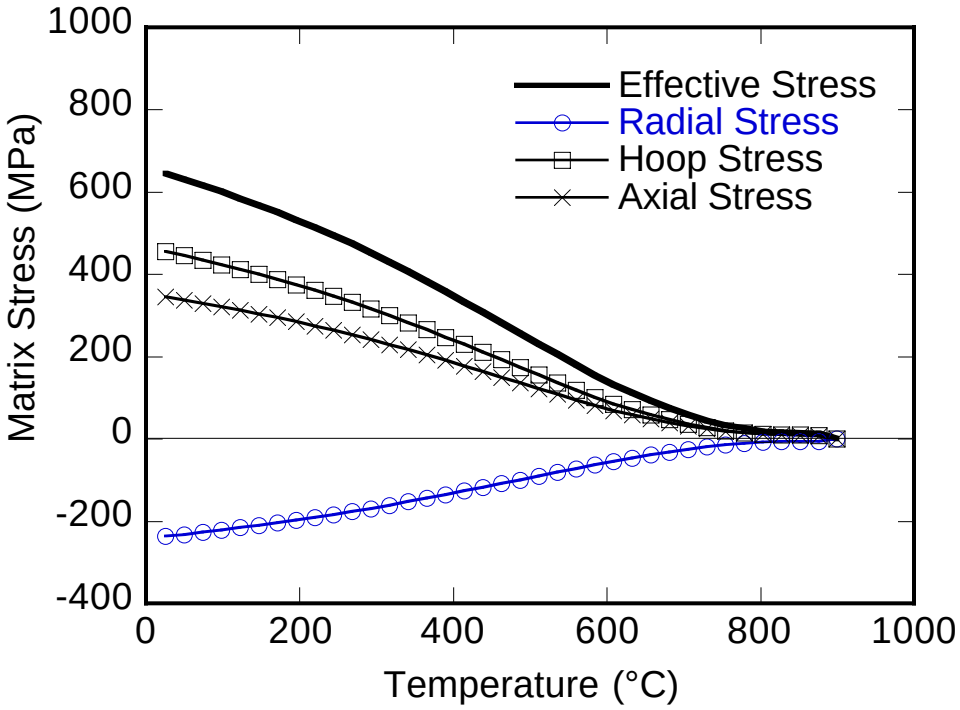


Figure 12. Stresses in the Matrix at the Fiber/Matrix Interface — Case 7.

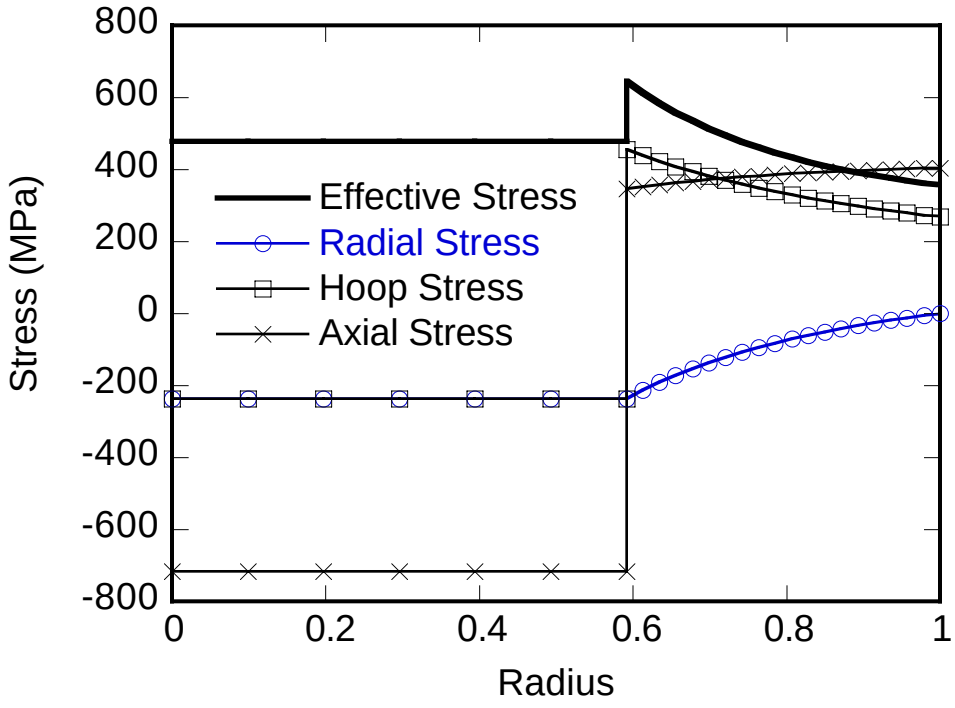


Figure 13. Stresses Across the Cross Section at Room Temperature — Case 7.

3.6 Thermomechanical Cyclic Behavior of CCM Under Mechanical Strain Loading (Case 8)

The CCM with elastic SCS-6 fiber and viscoplastic Timetal21S matrix is thermomechanically cycled after being cooled down to room temperature from a processing temperature of 900° C (Figure 14). The simulation is conducted under strain controlled loading. The input file is shown in Table 22. The average matrix and fiber stresses together with the total stress and temperature are shown in Figure 15. The stresses across the cross section at minimum temperature of the cycle, 150° C, are shown in Figure 16.

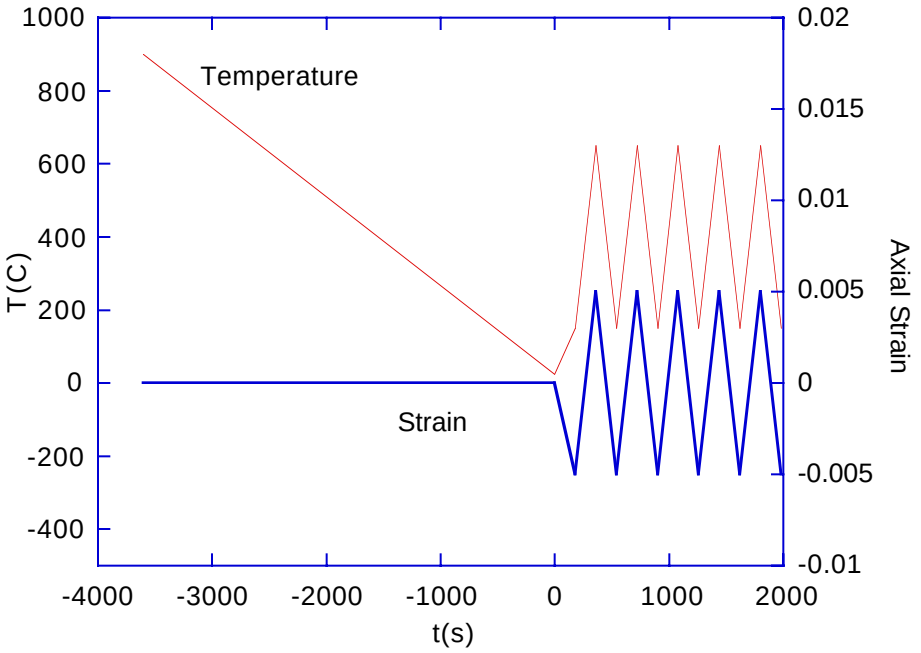


Figure 14. Loading History for Case 8.

Table 22. Input File for Case 8

```
SCS-6/TIMETAL21S(DBP) In-Phase TMF - strain control
1          1
sample_mat
2
BLOCK 1   NUMBER OF CYCLES   PRFREQ   PRSTART   INTOUT   NIOUT
          2                    1                 10       0              2                0
  Step      Time      Temp     Load      SR
     0       0.0     900.0      0.0      0.
  1000    3600.0      23.0      0.0      0.
BLOCK 1   NUMBER OF CYCLES   PRFREQ   PRSTART   INTOUT   NIOUT
          11                   1                 10       0              2                2
0   1100
  Step      Time      Temp     Load      SR
     0       0.0      23.0      0.0      0.
   100     180.0     150.0    -0.005    0.
   200     360.0     650.0     0.005    0.
   300     540.0     150.0    -0.005    0.
   400     720.0     650.0     0.005    0.
   500     900.0     150.0    -0.005    0.
   600    1080.0     650.0     0.005    0.
   700    1260.0     150.0    -0.005    0.
   800    1440.0     650.0     0.005    0.
   900    1620.0     150.0    -0.005    0.
  1000    1800.0     650.0     0.005    0.
  1100    1980.0     150.0    -0.005    0.

2
1    0.35      5
4    0.65      15
```

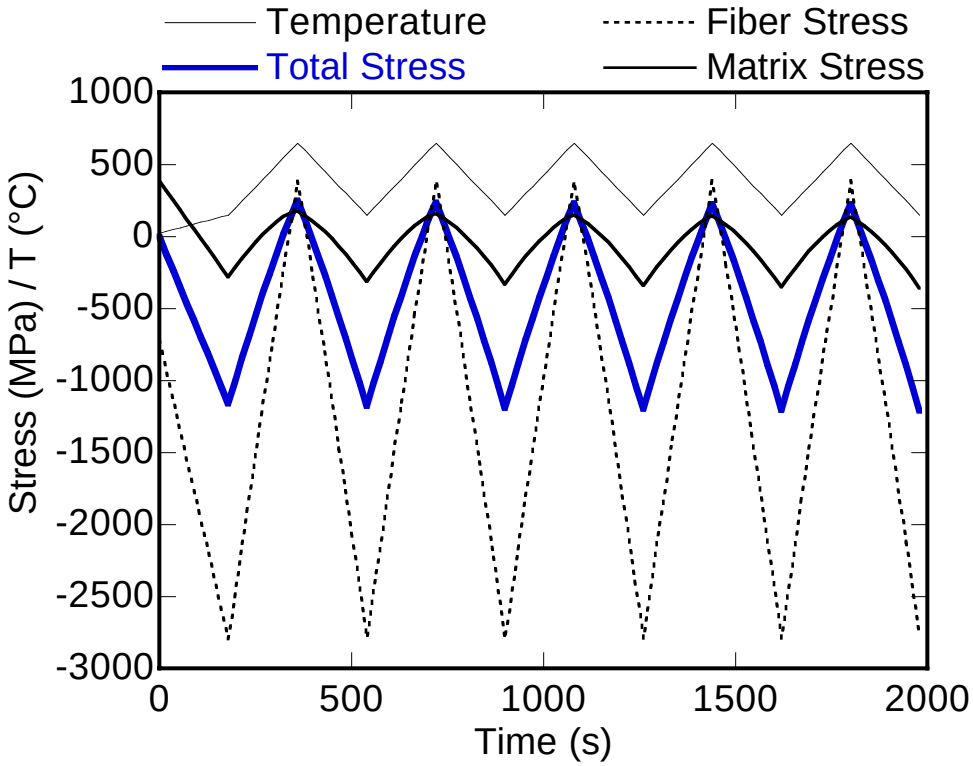


Figure 15. Average Stresses in the Matrix and Fiber.

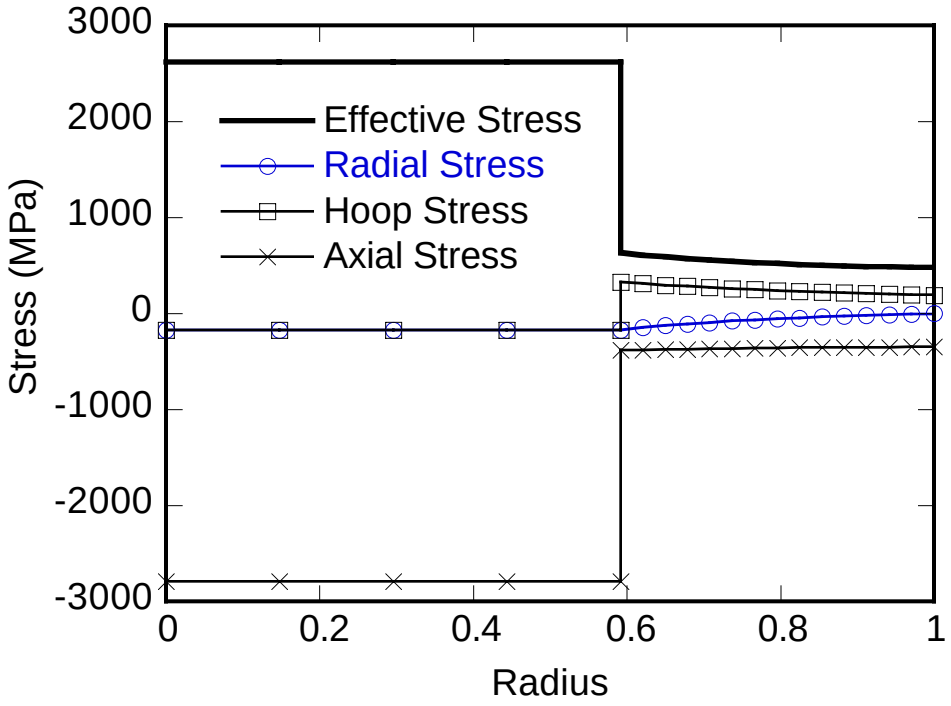


Figure 16. Stresses Across the Cross Section at 150° C.

3.7 Thermomechanical Cyclic Behavior of CCM Under Mechanical Stress Loading (Case 9)

The concentric cylinder model with elastic SCS-6 fiber and viscoplastic Timetal21S matrix is thermomechanically cycled after being cooled down to room temperature from a processing temperature of 900° C (Figure 17). The simulation is conducted under stress loading. The input file is given in Table 23. The average matrix and fiber stresses together with the total stress and temperature are shown in Figure 18. The stresses across the cross-section at minimum temperature of the cycle, 150° C, are shown in Figure 19.

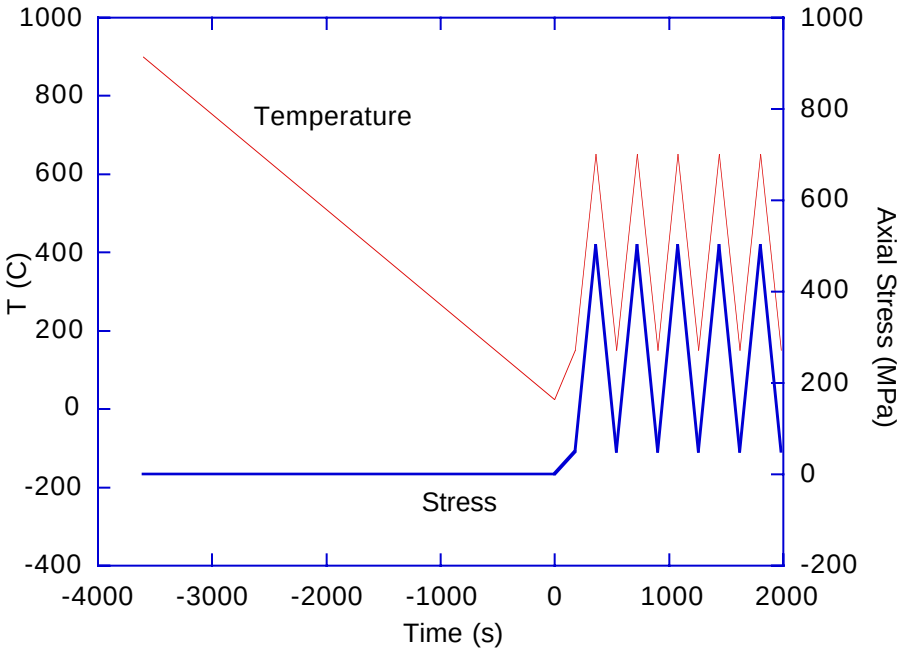


Figure 17. Loading History for Case 9.

Table 23. Input File for Case 9

```
SCS-6/TIMETAL21S(DBP) In-Phase TMF - stress control
1          0
sample_mat
2
BLOCK 1   NUMBER OF CYCLES   PRFREQ   PRSTART   INTOUT   NIOUT
          2                    1                10       0              2                0
  Step      Time      Temp     Load      SR
     0       0.0     900.0      0.0      0.
  1000    3600.0      23.0      0.0      0.
BLOCK 1   NUMBER OF CYCLES   PRFREQ   PRSTART   INTOUT   NIOUT
          11                   1                10       0              2                1
3200
  Step      Time      Temp     Load      SR
     0       0.0      23.0      0.0      0.
   200     180.0     150.0     50.0      0.
   400     360.0     650.0    500.0      0.
   600     540.0     150.0     50.0      0.
   800     720.0     650.0    500.0      0.
  1000     900.0     150.0     50.0      0.
  1200    1080.0     650.0    500.0      0.
  1400    1260.0     150.0     50.0      0.
  1600    1440.0     650.0    500.0      0.
  1800    1620.0     150.0     50.0      0.
  2000    1800.0     650.0    500.0      0.
  2200    1980.0     150.0     50.0      0.

2
1    0.35      5
4    0.65      15
```

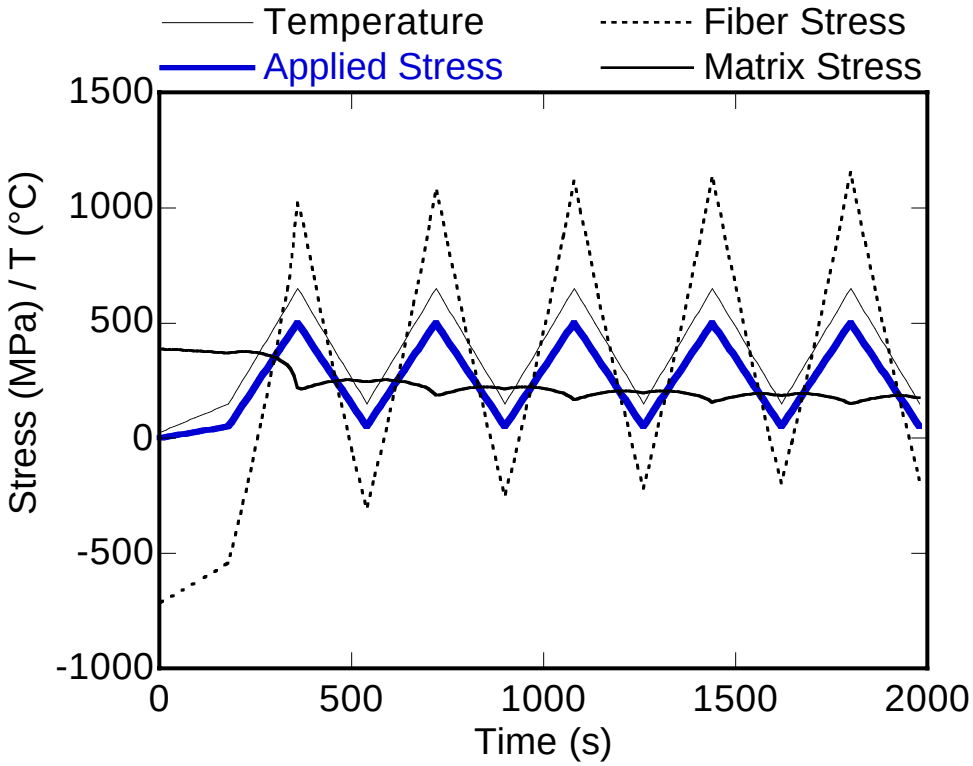


Figure 18. Average Stresses in the Matrix and Fiber.

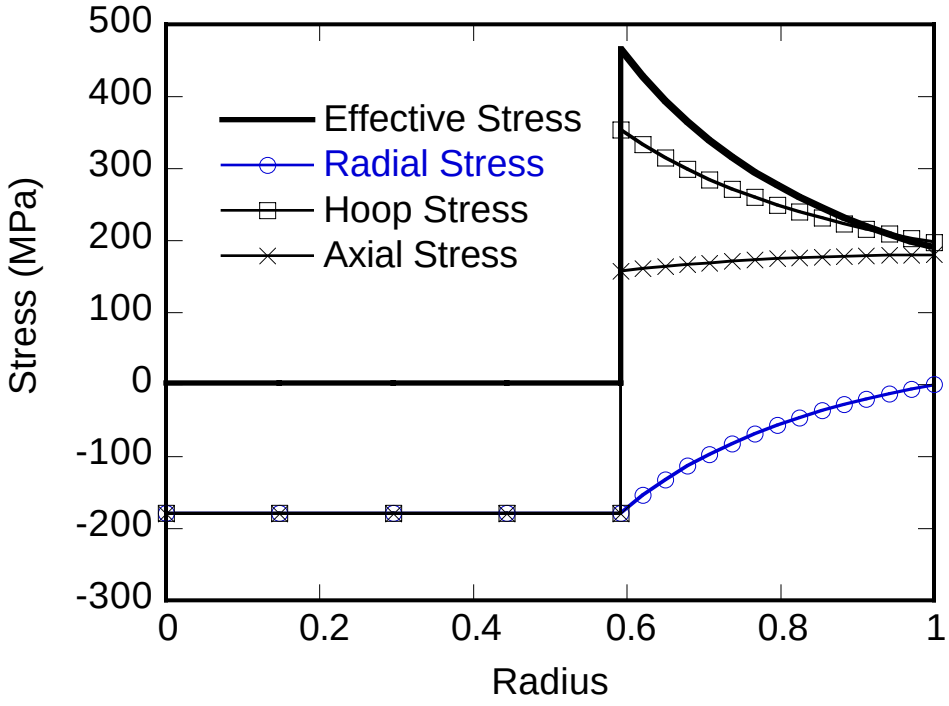


Figure 19. Stresses Across the Cross Section at 150° C.

3.8 Uniaxial Bar Using Bodner-Partom with Damage Model

This section presents three examples for the stress-strain behavior of a uniaxial bar using the Bodner-Partom with directional hardening and damage model. Loading/unloading paths are applied at 23° C and 650° C and a full reverse cyclic loading is applied to exercise the capabilities of the damage model.

3.8.1 Loading/Unloading Behavior at 23° C (Case 10)

The isothermal strain loading history at room temperature is shown in Figure 20 and the input file is shown in Table 24. The resultant stress-strain behavior is shown in Figure 21. As indicated in Figure 21, the modulus degrades with strain and regains original value during compression.

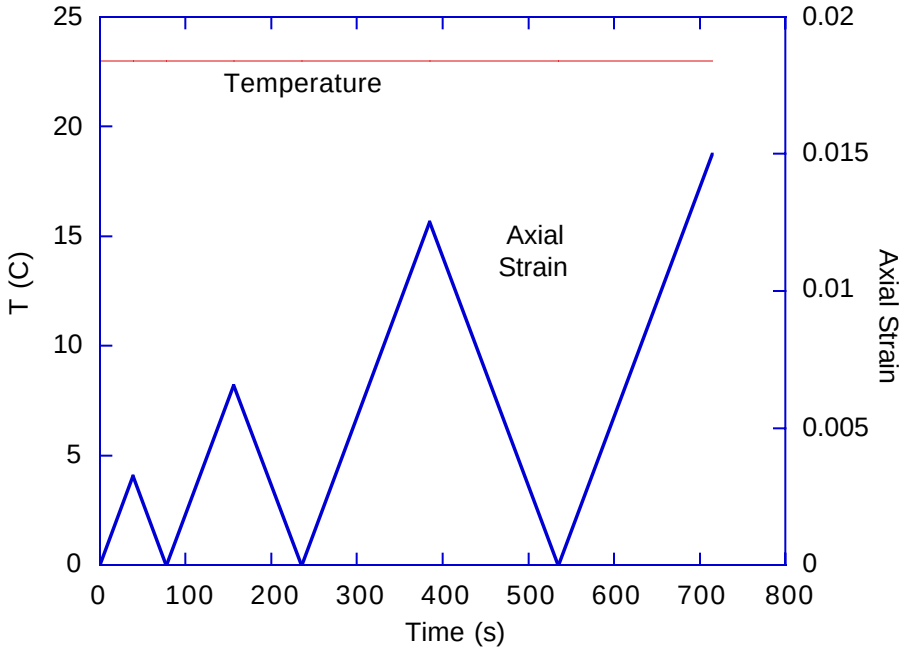


Figure 20. Loading History for Case 10.

Table 24 Input File for Case 10

```
Uniaxial Test of [90] Ply Damage Model
2          1
sample_mat
1
BLOCK 1   NUMBER OF CYCLES   PRFREQ   PRSTART   INTOUT   NIOUT
8                    1                    50       0              1              0
  Step      Time      Temp      Load       SR
     0       0.0      23.0       0.0       0.
  1000      39.0      23.0       0.00325   0.
  2000      78.0      23.0       0.0       0.
  3000     156.0      23.0       0.00325   0.
  4000     236.0      23.0       0.0       0.
  5000     385.0      23.0       0.00325   0.
  6000     535.0      23.0       0.0       0.
  7000     715.0      23.0       0.00325   0.

1
5   1.00      2
```

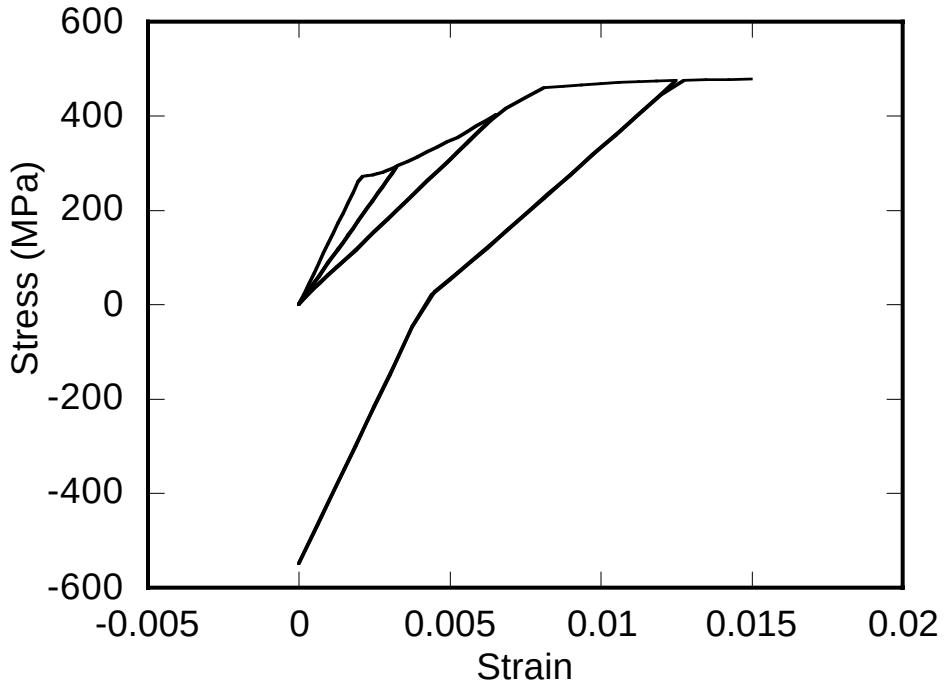


Figure 21 Stress-Strain Behavior for Case 10 (23° C).

3.8.2 Loading/Unloading Behavior at 650° C (Case 11)

The isothermal strain loading history at 650° C is shown in Figure 22 and the input file is shown in Table 25. The resultant stress-strain behavior is shown in Figure 23.

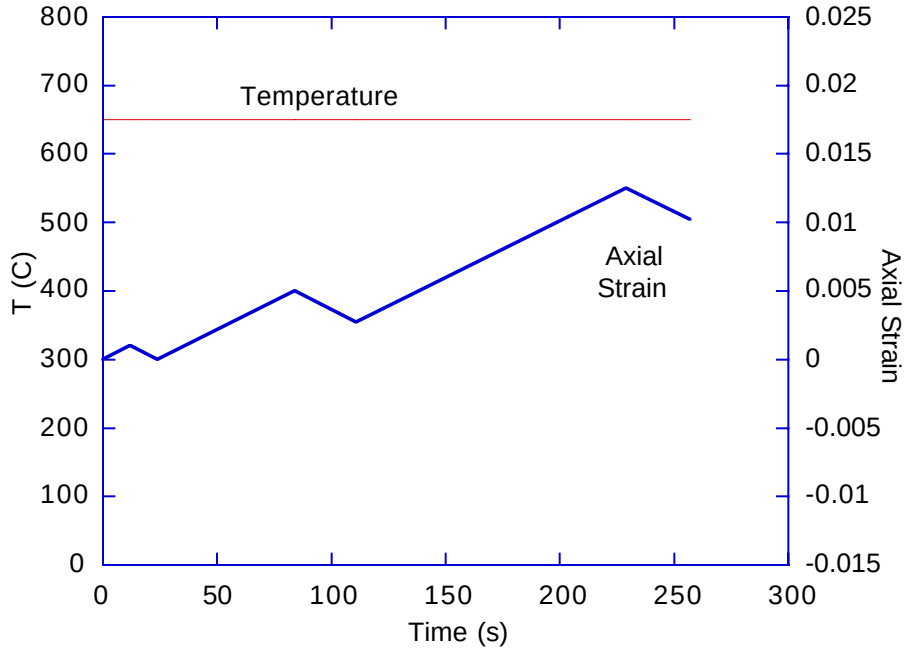


Figure 22. Loading History for Case 11.

Table 25. Input File for Case 11

Loading and Unloading Test of [90] Ply Damage Model at 650C

2 1

sample_mat

1

BLOCK 1 NUMBER OF CYCLES PRFREQ PRSTART INTOUT NIOUT

7 1 10 0 1 0

Step	Time	Temp	Load	SR
0	0.0	650.0	0.0	0.
120	12.0	650.0	0.001	0.
240	24.0	650.0	0.0	0.
840	84.0	650.0	0.005	0.
1110	111.0	650.0	0.002708	0.
2290	229.0	650.0	0.012484	0.
2570	257.0	650.0	0.010224	0.

1

5 1.00 2

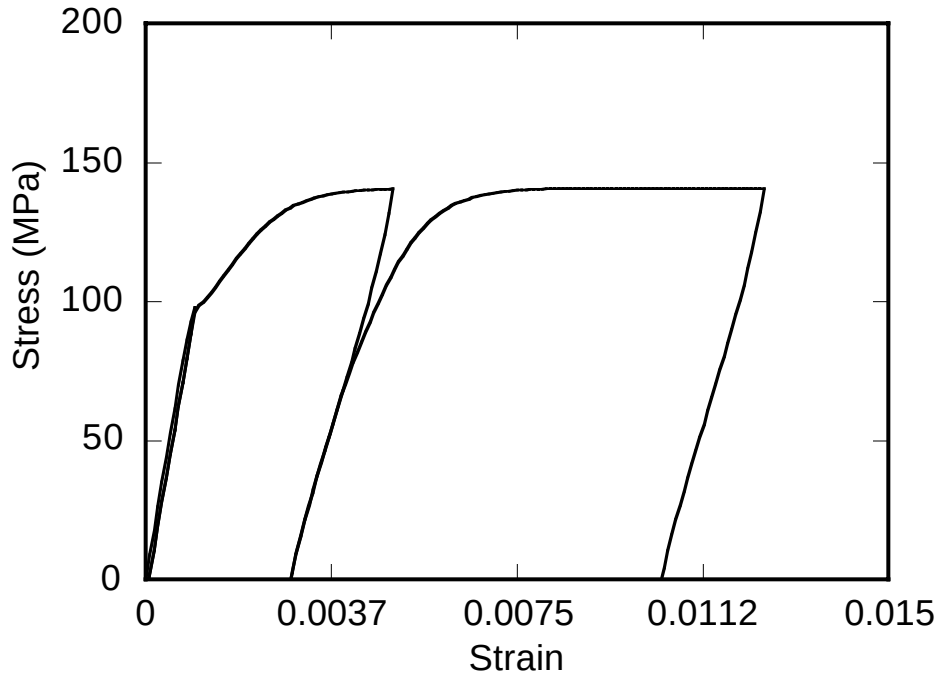


Figure 23. Stress-Strain Behavior for Case 11 (650° C).

3.8.3 Full Reverse Cyclic Behavior (Case 12)

The isothermal strain loading history at 650° C is shown in Figure 24 and the input file is shown in Table 26. The cyclic stress-strain behavior is shown in Figure 25.

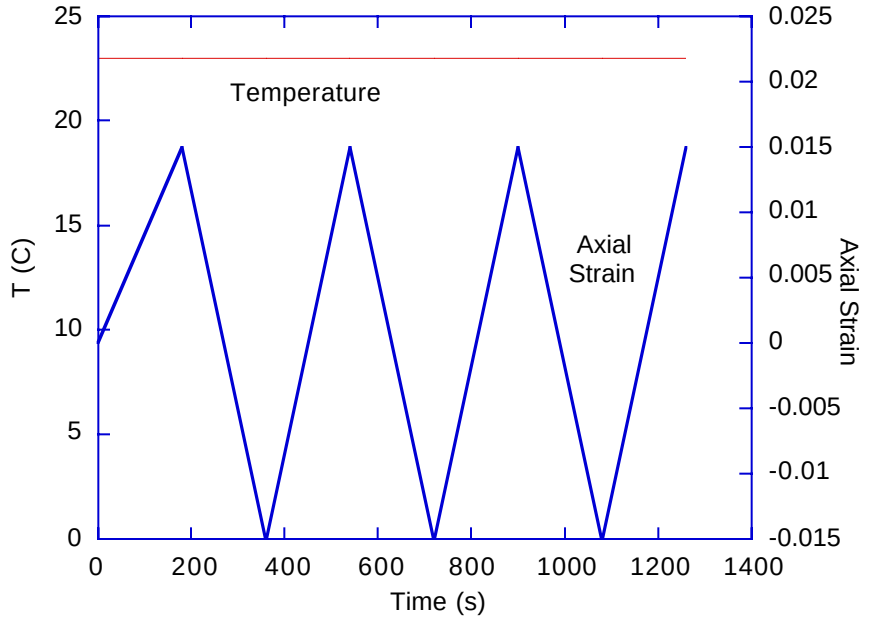


Figure 24. Loading History for Case 12.

Table 26. Input File for Case 12

```
Cyclic Test of [90] Ply Damage Model
2          1
sample_mat
1
BLOCK 1   NUMBER OF CYCLES   PRFREQ   PRSTART   INTOUT   NIOUT
          8                    1                10       0              1                0
 Step      Time      Temp      Load      SR
    0       0.0      23.0       0.0      0.
  180     180.0      23.0       0.015    0.
  360     360.0      23.0      -0.015    0.
  540     540.0      23.0       0.015    0.
  720     720.0      23.0      -0.015    0.
  900     900.0      23.0       0.015    0.
 1080    1080.0      23.0      -0.015    0.
 1260    1260.0      23.0       0.015    0.

1
5   1.00      2
```

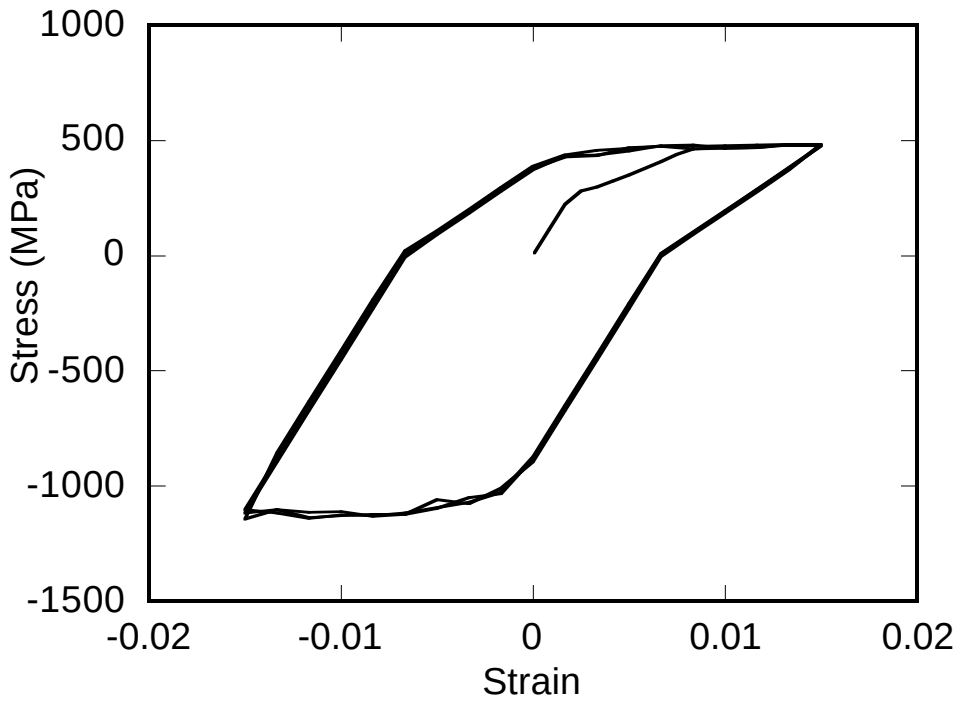


Figure 25. Stress-Strain Behavior for Case 12 (650° C).

SECTION 4
VERIFICATION OF SELECT PROBLEMS

The FIDEP2 source code has been extensively checked with solutions obtained from independent sources to provide confidence that numerical errors have been minimized. Cases from the demonstration problems from Section 3 were selected to verify that the numerical algorithms within FIDEP2 are functioning correctly, especially those cases containing highly nonlinear material response, e.g., the Bodner-Partom constitutive model.

4.1 Tensile Behavior of a Uniaxial Bar using Bodner-Partom with Backstress

The results in Section 3.1 (Case 1) for the Bodner-Partom model with backstress at 25° C have been compared against a solution in Figure 26 obtained from Mathematica. Mathematica is a differential equation solver which allows the precision of the solution to be selected by the user. For this particular case, the Mathematica solution, which was run on a SUN SPARC2 work station provided 7 or 8 digits of precision. The deviation of the FIDEP2 results from the Mathematica solution in Figure 26 indicates agreement to about 3%. The FIDEP2 solution is improved to less than 1.5% deviation when the number of solution steps is increased from 480 to 4,800.

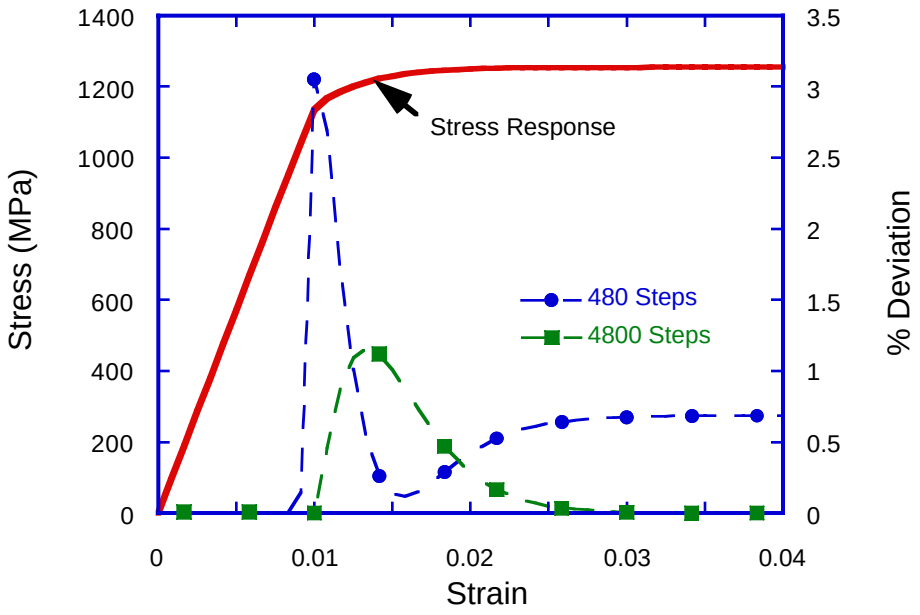


Figure 26. Tensile Behavior of the Bodner-Partom Model with Backstress at 25° C.

4.2 Uniaxial Bar under Thermal and Mechanical Loading

Results in Section 3.3 (Case 5) for the Bodner-Partom model with directional hardening have also been compared against the solution in Figure 27 obtained from Mathematica. Under the thermal and mechanical load in Figure 5, the deviation between the two solutions is well below 0.5% during isothermal loading and increases to less than 1.5% during nonisothermal conditions. Similar to the results found in Section 4.1, the error decreases with increasing number of solution steps, thus providing confidence that both viscoplastic algorithms are functioning correctly within FIDEP2.

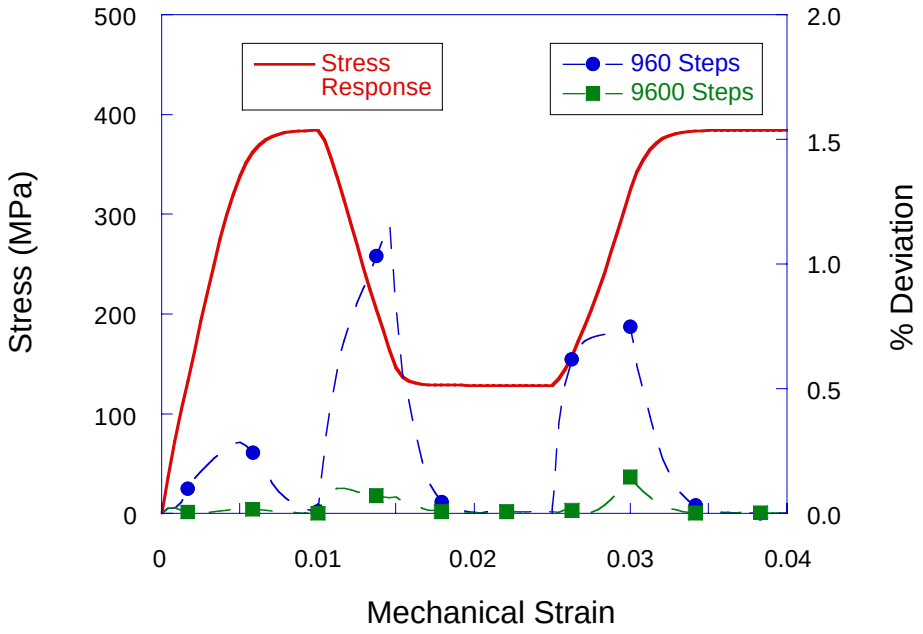


Figure 27. Comparison of FIDEP2 and Mathematica Solutions for Tensile Behavior of the Bodner-Partom Model with Directional Hardening.

4.3 Cool-Down Of A CCM - Elastic-Plastic Matrix

This verification case checks the bilinear elastic-plastic material model as well as the concentric cylinder geometry in Section 3.4 (Case 6). The loading is the same as that found in Figure 7, which is a cool-down from the processing temperature of an unidirectional metal matrix composite. The solution is compared with that obtained from a finite element method (FEM). The finite element mesh consists of forty-two 8-node axisymmetric elements that are solved with the finite element package ABAQUS. The number of elements is sufficiently high to give good accuracy (within an estimated 0.1%). The CCM within the FIDEP2 solution contained 21 nodes.

The matrix stress components at the fiber/matrix interface, illustrated in Figure 28, compare well between the FIDEP and FEM solutions (within 0.5 %). At room temperature, inspection of all of the stress components throughout the concentric cylinder (see Figure 29) also shows good

agreement between the two solutions which are also with 0.5% accuracy. The good agreement between the two solutions provides confidence that the elastic-plastic material response and the concentric cylinder model are functioning correctly within FIDEP2.

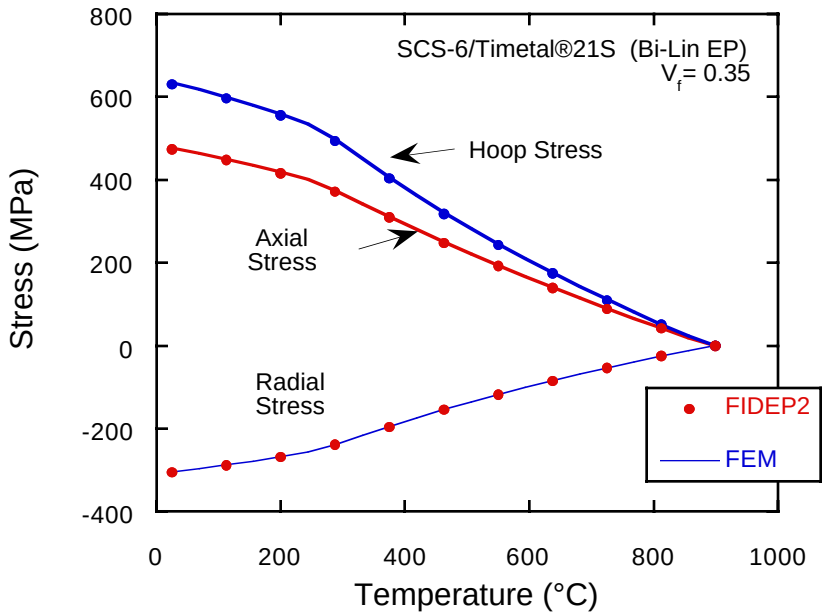
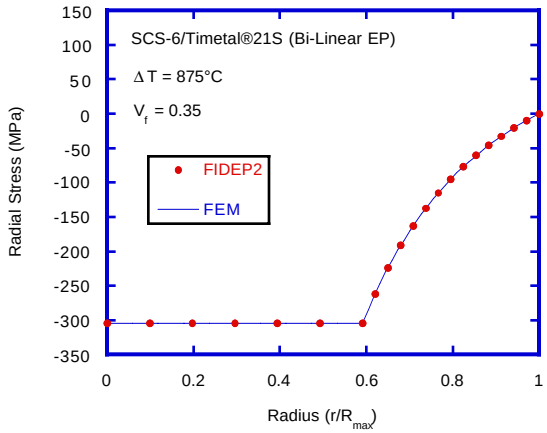
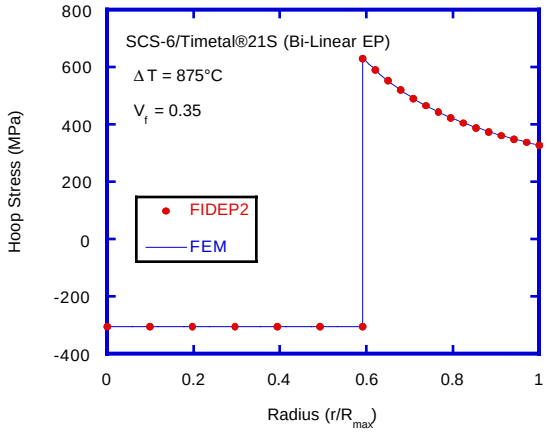


Figure 28. Matrix Stress at Fiber/Matrix Interface Comparison between FIDEP2 and the FEM with Elastic-Plastic Matrix Response.





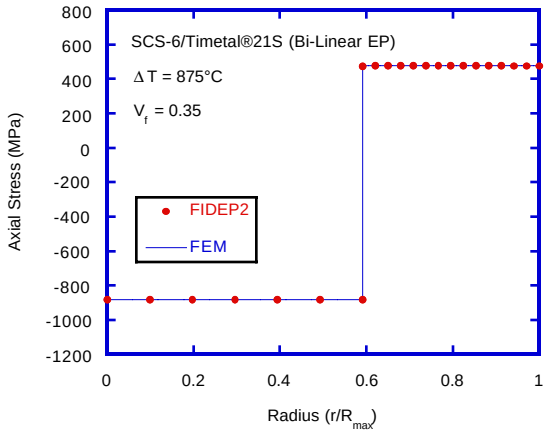


Figure 29. Comparison of Stress Components at Room Temperature from Cool-Down of a CCM with Elastic-Plastic Matrix.

4.4 Cool-Down of a CCM using Bodner-Partom with Directional Hardening Matrix

This verification problem checks the viscoplastic model of Bodner-Partom in conjunction with the concentric cylinder geometry in Section 3.5 (Case 7). The loading, given in Figure 7, is the cool-down of an unidirectional metal matrix composite from processing temperature. The only difference is the change from the previous elastic-plastic model for the matrix to a viscoplastic material response. The independent solution source for this case is also the FEM. The Bodner-Partom model is incorporated into the finite element package ABAQUS through user-subroutines [Kroupa, 1995]. The error from the finite element solution is estimated to be within 1 % for the boundary conditions prescribed.

The matrix stress at the fiber/matrix interface shown in Figure 30 also shows good agreement between FIDEP2 and FEM solutions, within 3%. Stress component throughout the concentric cylinder (see Figure 31) also shows good agreement (within 3%) between the two solutions. The accuracy of 3 % is not as good at the elastic-plastic case; however, the error is reasonable with respect to state-of-the-art viscoplastic algorithms. As noted from the previous viscoplastic cases, this error can be reduced with an increased number of solution increments.

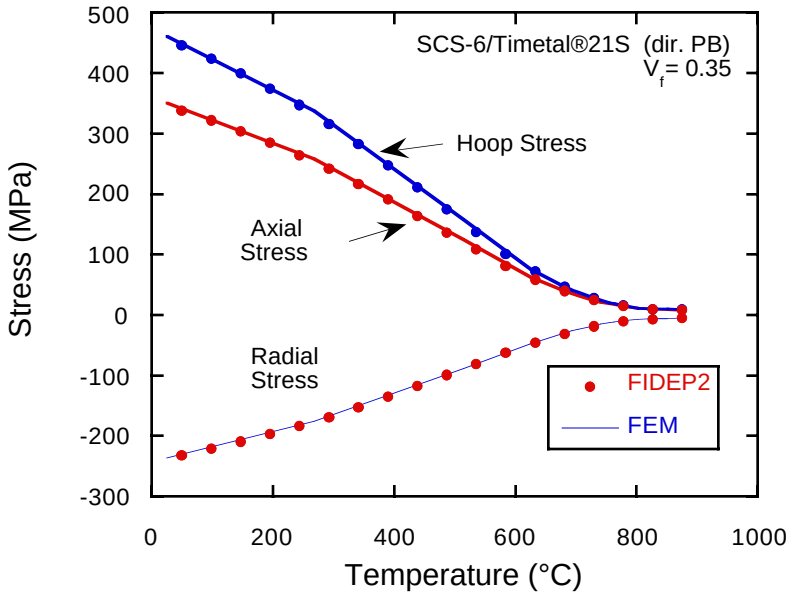


Figure 30. Matrix Stress at Fiber/Matrix Interface Comparison Between FIDEP2 and the FEM with Viscoplastic Matrix Response.

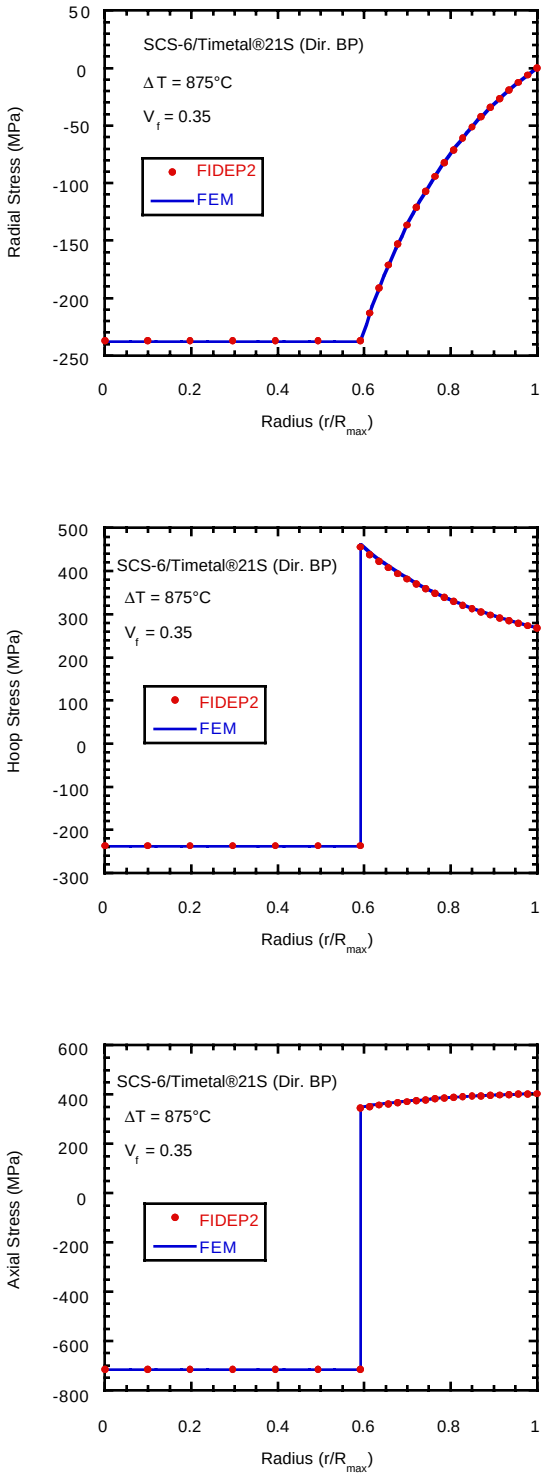


Figure 31. Comparison of Stress Components at Room Temperature from Cool-Down of a CCM with Viscoplastic Matrix.

4.5 Uniaxial Bar using Bodner-Partom with Damage Model

The last verification problem of interest is the tensile loading and unloading of a uniaxial bar. The constitutive model represents damage evolution in a transversely loaded unidirectional metal matrix composite. The independent solution source is a special purpose C-program that was designed to solve the complex set of equations. For the demonstration problem of Section 3.8.2 (Case 11), the comparison of the FIDEP2 and the C-program solutions is shown in Figure 32. The stress-strain response consists of repeated loading and unloading stages with progressively increasing strain levels (see Figure 22). This type of loading triggers the damage evolution in the material response model. Generally, the results from the two analyses are within 1.5 % of each other during loading and unloading, as illustrated in Figure 33. The accuracy of the C-program is estimated to be within 1.5 %. The good agreement between these two solutions provides confidence that the numerical algorithms used to solve this progressive damage model are functioning correctly.

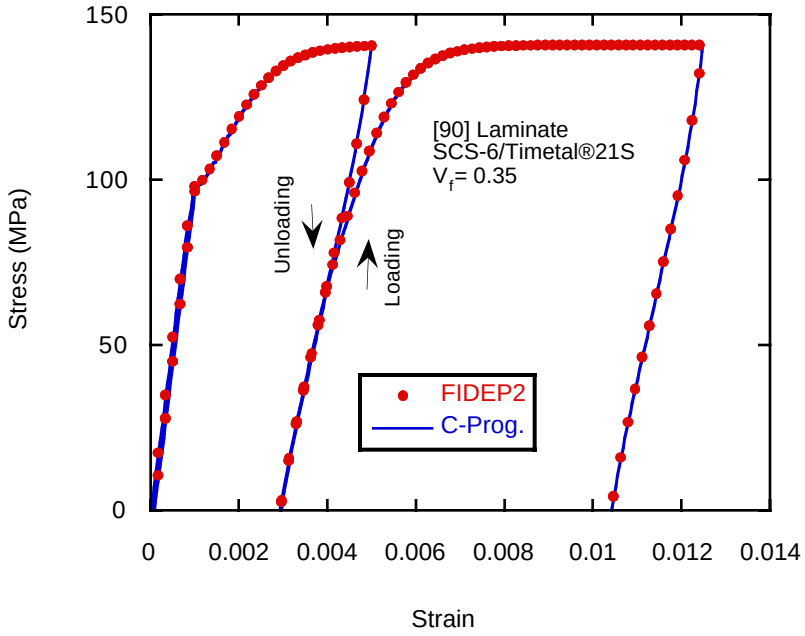


Figure 32. Stress-Strain Response of [90] Laminate Damage Model at 650° C.

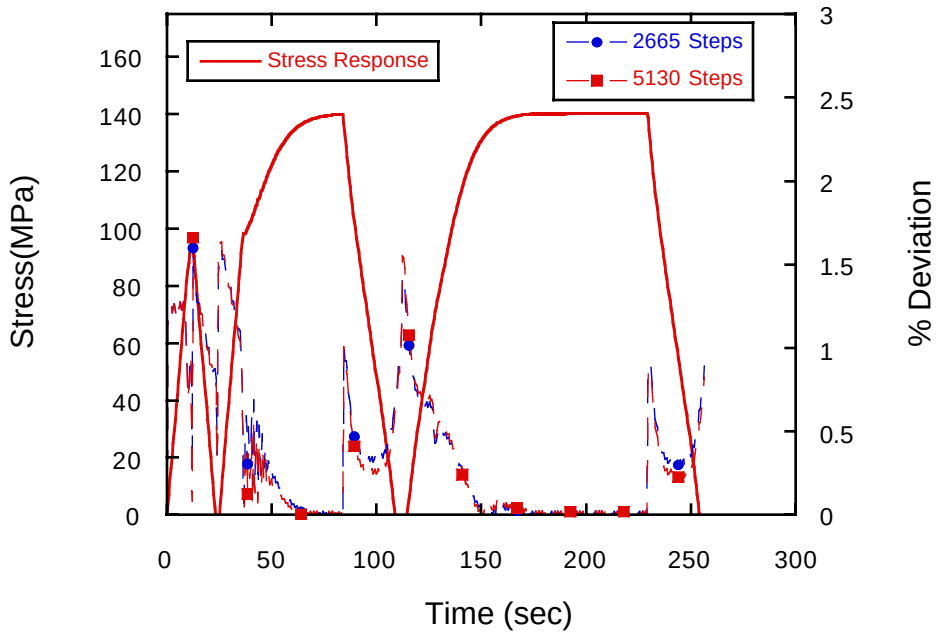


Figure 33. Solution Deviation of Stress Response from FIDEP2 and C-Program Output.

4.6 Summary of Verification Cases

The verification cases presented in this section demonstrate that all of the numerical algorithms within FIDEP2 are functioning correctly. As expected, the viscoplastic models exhibited more error than the bilinear counterpart. However, the errors occurring in these highly nonlinear cases are generally reduced by increasing the number of solution increments.

SECTION 5
PROGRAM DESCRIPTION

FIDEP2 efficiently predicts the stress and strain distributions in a composite under processing conditions and complex thermomechanical fatigue loading histories with axial and radial stress- or strain- controlled loading [Coker and Ashbaugh, 1992]. A listing of FIDEP2, Version 8, code is given in Appendix D. FIDEP2 is written in a modular form to allow for different micromechanical and nonlinear constitutive models. Other types of micromechanical models can be added to the program, provided that the total stresses are written in terms of the inelastic strain increments. Time-independent inelastic behavior of the constituents can be represented by bilinear elastic-plastic formulation ,and the viscoplastic behavior of the constituents can be represented by the Bodner-Partom unified strain theory incorporating backstress [Ramaswamy, et al., 1990] or directional hardening [Chan, et al., 1988] formulations. The incremental iterative algorithm for computing stresses and inelastic strains makes use of the successive elastic solutions technique [Mendelson, 1968] and is explained further in Section 6. The same subroutine that is used for all material models is explained in section 5.2. The pseudocodes are given in section 5.3. Finally, the placement of the nodes in the CCM is explained in section 5.4.

5.1 General Outline of FIDEP2

FIDEP2 code uses a successive elastic solutions technique to determine the inelastic behavior of the material. The general outline of the program consists of the following steps:

1. Initialize variables.
2. Read Input.
   a) Loading history, type of loading, type of micromechanical model (ICASE)
   b) Type of constitutive model and corresponding temperature-dependent material properties for each component (ITYPE)
3. Compute new secant CTE with respect to the initial temperature in the loading file, if different from the reference temperature of CTE.
4. Define node locations for each component for the CCM case.
5. Apply the thermal and mechanical load increment.
6. Interpolate to compute the mechanical properties at the current temperature, and assign properties to each node.
7. If the CCM is used, compute L-U decomposition for the A-matrix.
8. Solve the boundary value problem for the appropriate micromechanical model, and compute estimates for the stresses assuming an elastic load increment.
9. Compute incremental inelastic strain estimates using the flow rule and the numerical integration scheme corresponding to the constitutive behavior of each component.
10. Compute new stress estimates using the new inelastic strain increments.
11. Compute internal state variable increments from the evolution equations.
12. Repeat steps 9 - 11 until convergence is obtained for the effective inelastic strains or the stresses.
13. If convergence of the stresses and strains is reached, repeat from step 5 until the end of the loading history is reached.

The constitutive model is defined by ITYPE in the input material data file. In addition to the available material models, a user-defined constitutive model can be added to the program. To

add a new constitutive model, the following three changes have to be made in the program: (a) add new common statements, (b) define new material property names in SUBROUTINE PROPNODES, and (c) add the new equations to SUBROUTINE INELASTIC.

The problem type is defined by ICASE in the input file. In addition to the available micromechanical models, other stress solutions could be added to the program. The first step is to solve for the stresses in terms of the plastic strain increments for the new problem. The new equations can then be added by creating a new SUBROUTINE STRESS4, and additional IF statements can be added in SUBROUTINE STRESS and SUBROUTINE GEOMETRY.

5.2 Subroutine for Constitutive Models

After determining the elastic estimates for the stresses, SUBROUTINE INELASTIC is called. This subroutine uses a different algorithm to compute the plastic strain increments for each component with different constitutive models. As a result, different viscoplastic models for each component of the composite can be used. The flowchart for FIDEP2 is as follow:

```
      Apply incremental load
      Determine elastic estimate for stresses
10    Do k=1, number of materials
            IF( ITYPE(k) = 1 ) THEN
                  Goto next material
            IF( ITYPE(k) = 2 ) THEN
                  For all nodes in material k
                  Elastic-Plastic Algorithm for De_ij^p
                  ...
            IF( ITYPE(I) = 5 ) THEN
                  For all nodes in material k
                  Bodner-Partom Algorithm for De_ij^p
            ENDIF
      Compute new plastic strain estimates at all nodes
      ENDDO
      Determine stresses using the plastic strain estimates
      Goto 10 until convergence of the stresses and strains is obtained.
      Goto next loading increment.
```

The differences between the algorithm described in section 6.2.2 for elastic-plastic material and the straightforward Euler algorithm used for the unified strain theory algorithms is illustrated below for the Bodner-Partom with backstress model.

```
      Elastic-Plastic Algorithm
0     Compute elastic estimates for stresses
1     For each node
2           Estimate incremental plastic strain
3           Compute effective incremental plastic strain
4           Compute effective stress
5     Compute stresses with the assumed plastic strain increment
6     For each node
```

7 Compute new incremental plastic strain using results from steps 3, 4, 5
8 Repeat.

Viscoplastic Algorithm for Bodner-Partom with Backstress

0 Compute elastic estimates for stresses
1 For each node
2 Compute effective stress
3 Compute effective incremental plastic strain, deff, from Bodner-Partom equation
4 Estimate incremental plastic strain from deff
5 Compute stresses with the assumed plastic strain increment
6 For each node
7 Compute incremental backstress
8 Goto 1.

5.3 Pseudocode

The pseudocode for the main program is given in Table 26. The pseudocodes for the individual subroutines called from the program are given in Table 27.

5.4 Node Assignment in the CCM

For the CCM, given the number of materials or cylinders, number of nodes in each cylinder, and lthe volume fraction of each material, the distribution of the nodes in each cylinder are computed using the following quadratic polynomial:

$$r_i = a_n + (a_{n+1} - a_n)\frac{(k_i^2 - 1)}{(k_{\max_n}^2 - 1)} \qquad (1)$$

where i = 1,..., NTOT,
n = 1,..., NOMAT
ki = 1,..., kmax
r is the distance from the center of the nodes
an and an+1 are the inner and outer radius of the nth cylinder
NTOT is the total number of nodes
NOMAT is the number of materials
kmaxn is the number of nodes in cylinder n.

The distribution of the nodes is denser near the interface, and more accurate stresses are obtained as compared to a uniform distribution because of a large stress gradient at the interface. The effect on the stresses is noticeable for a very small fiber volume fraction, which simulates a single fiber in an infinite matrix. The core cylinder is automatically divided into three nodes since there is no stress or strain variation in the core. In addition, the innermost node in each cylinder is moved away from the interface and is located halfway between the interface and the next node.

Table 27. Pseudocode for FIDEP2

MAIN PROGRAM FIDEP2_6

```
Initialize the material property and loading arrays
    CALL INITIAL( ITYPE, EP2, XT1 )

Read loading conditions, geometry and output preferences
    CALL READLOAD( NLOAD )

Read input data; constitutive model and corresponding properties
    CALL READMAT( ITYPE )

Compute new cte if reference temp is not the same as the first temperature in the loading
file
    CALL NEWCTE( BT(1) )

Rewind and close input files
    CALL CLOSEFILES

Write loading and material data into output file 15
    CALL WRITEMAT( ITYPE )

Define physical and geometric parameters
    CALL GEOMETRY

Fix zero stress state temperature as the first temp in the data file

Reset counter        ICOUNT = 0

Start block loading from input file

Start incremental loading for each block in input file
```

Table 27. Pseudocode for FIDEP2 (Continued)

```
Start counter ICOUNT = ICOUNT + 1

Compute total and incremental temperature, applied stresses,applied strain, and time
        CALL LOAD( IB, NSTEPS, ISTEP, BT(1) )

Interpolate for material properties at temperature T
        CALL PROPT( ITYPE, T )

Assign material properties to nodes and multiply by appropriate constants to account for
units such as MPa etc. in input file
        CALL PROPNODES( ITYPE, ICOUNT )

For concentric cylinder model create A-matrix and the L-U decomposition
        IF(ICASE .NE. 2) CALL AMATRIX( ICOUNT )

Compute stresses assuming elastic behavior
        CALL STRESS( EP2, ICOUNT )

Compute inelastic strain increments and iterate to converge to right combination of stresses
and strains.
                CALL INELASTIC( ICOUNT, ITYPE, EP2 )

Output results at the end of incremental loading
                CALL OUTPUT1( ICOUNT, ITYPE, EP2, BS )

Goto next step

Go to next block in input file

Stop
End
```

Table 28. Pseudocode for the Subroutines in FIDEP2

SUBROUTINES

SUBROUTINE INITIAL
Initialize variables

SUBROUTINE READLOAD
Read loading conditions, geometry and output preferences
Assigns ICASE, ILOAD
GEOMETRY TYPE
    IF(ICASE .EQ. 1) Concentric Cylinder Model
    IF(ICASE .EQ. 2) 1-D Laminate Model
    IF(ICASE .EQ. 3) Concentric Cylinder Model with [90]
LOADING TYPE
    IF (ILOAD .EQ. 0) Stress Control
    ELSE Strain Control
Printout at every n steps: IPRINTSTEP
Start Printout at steps: ISTEPOUT

SUBROUTINE READMAT
Read constitutive model type and temperature-dependent properties for materials defined by the load file. This subroutine reads both temperature-dependent and independent elastic and inelastic material properties for any constitutive model into material, row, column array tp(i,j,k).

Go though each material, until you find your material
Then for each material
    Read the elastic material properties
    Inelastic material properties are given in this many sets
    Read the inelastic material properties
    Note: If only one row of data then there is no temp variable
Goto next material if material number is not what is wanted
Store the materials that are used
Read material type ITYPE for each material
Assign ITYPE, Constitutive model:
    IF(ITYPE(K) .EQ. 1) Elastic
    IF(ITYPE(K) .EQ. 2) Bilinear Elastic-Plastic #1
    IF(ITYPE(K) .EQ. 3) Bilinear Elastic-Plastic #2
    IF(ITYPE(K) .EQ. 4) Viscoplastic with Damage
    IF(ITYPE(K) .EQ. 5) Bodner-Partom with Back Stress
    IF(ITYPE(K) .EQ. 6) Bodner-Partom with Directional Hardening
IDAMAGE = 0
Bodner-Partom with direct hard and damage is automatically redefined as ITYPE = 6 and IDAMAGE = 1
If material type is found and stored, continue with next material

Table 28. Pseudocode for the Subroutines in FIDEP2 (Continued)

SUBROUTINE NEWCTE
Compute new cte if reference temperature is not the same as the first temperature in the loading file

FAC is used to extrapolate for the new cte at the new ref temp due to the fact that the new cte is infinity here.

For interpolations between temperatures (general case) JFAC=0
Compute new secant CTE with respect to the initial temperature that is given in the loading file, i. e. TPROC.
Replace the old CTE table with the new CTE table
Compute new CTE wrt processing temperature

If the new processing temperature is one of the data points then interpolate between the previous and the next CTE.

SUBROUTINE WRITEMAT
Write material data into output file 15

SUBROUTINE LOAD
Interpolate for applied loading, time and temperature
Compute increments in temperature, applied stress, total applied strain and time using FUNCTION XNEW = ISTEP*(X2 - X1)/NSTEPS + X1

SUBROUTINE PROPT
Interpolate for material properties at temperature T

FUNCTION CURVE
Material properties given as an explicit function of temperature
if(id_cur .eq. -9999) CURVE = 5.8E5*EXP(-1.37E4/(T+273))

Table 28. Pseudocode for the Subroutines in FIDEP2 (Continued)

SUBROUTINE PROPNODES
Assign material properties to nodes and multiply by appropriate const

Elastic properties at the nodes
    CALL ELAS(IM, K)
Compute composite modulus and composite CTE

Inelastic properties at the nodes, the arrays are given physical names for each node
    For each material
    IF(ITYPE(IM) .EQ. 1) goto next material
    IF(ITYPE(IM) .EQ. 2) for each node CALL MAT2(IM, K)
    IF(ITYPE(IM) .EQ. 3) for each node CALL MAT2(IM, K)
    IF(ITYPE(IM) .EQ. 4) already reassigned as ITYPE=6 IDAMAGE=1
    IF(ITYPE(IM) .EQ. 5) for each node CALL MAT5(IM, K, ICOUNT)
    IF(ITYPE(IM) .EQ. 6) for each node CALL MAT6(IM, K, ICOUNT)
    IF(ITYPE(IM) .EQ. 7) for each node CALL MAT7(IM, K, ICOUNT)

SUBROUTINE ELAS(I, K)
    For damage in [90] define TEO(K) = TE(K)
SUBROUTINE MAT2(I, K)
SUBROUTINE MAT5(I, K, ICOUNT)
SUBROUTINE MAT6(I, K, ICOUNT)
    IF(IDAMAGE(I) .EQ. 1)assign values to damage parameters
SUBROUTINE MAT7(I, K, ICOUNT)

SUBROUTINE AMATRIX
For concentric cylinder model case (for ICASE = 1, 3), create A-matrix and the L-U decomposition at this loading step to determine radial and hoop stresses.
Subtract 2 nodes from the total number of nodes for ICASE=3 because there is no effect of [90] ply on the radial stresses except through the axial stresses => NTOT = NTOT - 2 and NOMAT = NOMAT - 1

Define matrix dimension => NRA = 2*(NTOT - 1)
Fill in the elements for the A-matrix

Take the limits for the first terms in left submatrices

Skip the addition to the amatrix during strain loading
  IF(ILOAD .EQ. 1 .AND. ICOUNT .GT. ISTRAIN)GOTO 55

Add additional terms in equations for interface nodes

If radial loading is applied, add term BMAT(NTOT-1) = SR

Compute the LU factorization of AMAT and store in AMAT
    CALL LUDCMP(AMAT,NRA,LDA,IPVT,D)

Add back 2 nodes to the total number of nodes for ICASE=3
    IF(ICASE .EQ. 3) NTOT = NTOT + 2 and NOMAT = NOMAT + 1

Table 28. Pseudocode for the Subroutines in FIDEP2 (Continued)

SUBROUTINE STRESS

Compute stresses assuming elastic behavior for the last load incr.

For damage model reduce stiffnes here

```
IF( IDAMAGE(I) .EQ. 1 )for each node in material
    DO 8 J = ibeg(I), iend(i)
    TE(J) = TEO(J)*(1.0-ETA(J)*D(J))
```

Compute new composite modulus and cte, ECOM and CTECOM

```
ECOM = ECOM + TE(J)*VF(I)
CTECOM = CTECOM + TCTE(J)*TE(J)*VF(I)
CTECOM = CTECOM/ECOM
```

For each material

```
for icase 1 - concentric cylinder
    CALL STRESS1( EP, ICOUNT )
for icase 2 - Lamina model
    CALL STRESS2( EP, ICOUNT )
for icase 3 - concentric cylinder with [90]
    CALL STRESS3( EP, ICOUNT )
```

Compute total strains at all nodes from stresses calculated above
Compute effective stress and deviatoric stresses

```
SEFF(J) = CSEFF( J )
CALL DEVIATS( J )
```

SUBROUTINE STRESS1

Solves stress state for multiple concentric cylinder model
Calculate total strain:
a) For strain controlled loading after cool down ez*=eztot
    IF(ILOAD .EQ.1 .and. ICOUNT .GT. ISTRAIN) THEN
    EZSTAR = EZ + EZCOOL and EZTOT = EZSTAR
b) For stress controlled loading calculate EZSTAR from integral
    sum(2/b^2*E/Ec* integral(ezp*rdr))

Complete B matrix by calculating plastic term PP(I) using EZSTAR in "function plastic".
Add contribution of sr term to the last term in bmat
Using Bmat, and the L-U decomposition of Amat determine XSOL, the vector of radial and hoop stresses

```
CALL LUBKSB(AMAT,NRA,LDA,IPVT,BMAT,XSOL)
```

Compute stresses from the XSOL solution vector
Use Boundary conditions

```
S(1,NTOT2) = SR
S(2,1) = S(1,1)
```

Compute total axial strain for stress controlled cases from ez*
Compute axial stress from the axial stress-strain equation

Table 28. Pseudocode for the Subroutines in FIDEP2 (Continued)

SUBROUTINE STRESS2

Solves Stress state for 1-D lamina model, multiple laminates
Calculate total strain:
a) For strain controlled loading after cool down ez*=eztot
IF(ILOAD .EQ. 1 .AND. ICOUNT .GT. ISTRAIN)
EZSTAR = EZ + EZCOOL and EZTOT = EZSTAR or
b) For stress controlled loading calculate EZTOT from equations
Compute uniaxial stress as a function of eztot and epestimate

SUBROUTINE STRESS3

Solves stress state for CCM with [90]
Calculate total strain:
a) For strain controlled loading after cool down ez*=eztot
IF(ILOAD .EQ.1 .and. ICOUNT .GT. ISTRAIN) THEN
EZSTAR = EZ + EZCOOL and EZTOT = EZSTAR
b) For stress controlled loading calculate EZSTAR from integral
sum(2/b^2*E/Ec* integral(ezp*rdr))

For the following use NTOT2=NTOT - 2 nodes to neglect effect of [90] ply
Complete B matrix by calculating plastic term PP(I) using EZSTAR in "function plastic".
Add contribution of sr term to the last term in bmat
Using Bmat, and the L-U decomposition of Amat determine XSOL, the vector of radial and hoop stresses

CALL LUBKSB(AMAT,NRA,LDA,IPVT,BMAT,XSOL)
Compute stresses from the XSOL solution vector
Use Boundary conditions
S(1,NTOT2) = SR
S(2,1) = S(1,1)
Compute total axial strain for stress controlled cases from ez*
Compute axial stress from the axial stress-strain equation

FUNCTION PLASTIC

Computes special plastic term in Concentric Cylinder Model

SUBROUTINE GEOMETRY

Define geometric properties NTOT, IBEG and IEND for each material
IF (ICASE .EQ. 2) only one node
Compute total number of nodes, NTOT
Compute radii limits for each material Block
Compute location of nodes

SUBROUTINE INELASTIC

Compute inelastic strain increments and iterate to converge to the right combination of stresses and strains

If all the materials are elastic, then return to main
Calculate initial yield surfaces for elastic-plastic material and check for plasticity
SE(J) = YSURFACE(EPEFF(J), J)

Table 28. Pseudocode for the Subroutines in FIDEP2 (Continued)

```
Plastic step starts here

Compute estimates for plastic strain increments except for ITYPE = 2
Compute estimates for backstress model
Compute estimates for directional Bodner Model
    MAXITER = 150
    RELAX   = 0.8
Start Iterations for inelastic strains

        Compute new estimates for the plastic strain increments
        For each material ITYPE
          IF ITYPE = 2, Bilinear Elastic-Plastic
                at each node for J = IBEG(I), IEND(I)
                Calculate modified total strains
                Relationship between dep or psi and eff MTS
                Calculate new PSIs using modified P-R equations

         IF ITYPE = 3, Bilinear Elastic-Plastic with 2nd el-pl algorithm
                Check stress state for yielding at node j
                If F<0 during iterations, still iterate for conv.
                For algorithm 2 start iterations with nonzero ep
                Compute equivalent plastic strain
                Compute the yield surface, se from epeff
          IF ITYPE = 5, Bodner-Partom with backstress
          IF ITYPE = 6, Bodner-Partom with directional hardening

        Compute Stresses given the plastic strain estimates
                CALL STRESS( EP2, ICOUNT )
        Evolution equations for the internal state variables
        Calculate effective stress as a combination of seff at old and new
        time step
        SEFF(J) = SEFF(J)*(1.0-relax)+SEFFOLD(j)*relax

        Check for convergence using difference between effective stresses and/or effective
plastic strains
        IF( ITER .GT. 4 .AND. ERROR .LT. TOLER ) goto next loading incr.
        IF( ITER .EQ. MAXITER ) no convergence

ITERATION LOOP
END OF ITERATIONS
print out at selected number of steps

Update state variables
        IF( ITYPE(I) .EQ. 5 ) at each node in material I ...
        IF( ITYPE(I) .EQ. 6 ) at each node in material I ...
                IF(IDAMAGE(I) .EQ. 1 ) update damage properties
                Compute work rate, ssum, bsum=SQRT(bij*bij)
                Compute v(i) and u(i) vectors
```

Table 28. Pseudocode for the Subroutines in FIDEP2 (Continued)

Compute directional hardening ZD = bijuij
Compute isotropic hardening ZI = bij*uij
When ZD becomes negative we get nonconvergence
Compute total drag stress
IF(IDAMAGE(I) .EQ. 1) ZTOT(J) = ZTOT(J)*(1-ETA(J)*D(J))
IF(S(3,J) - DSM - DSCHNEW .GT. SPEAK) update Speak

SUBROUTINE OUTPUT1
Print output

SUBROUTINE INTERPOL
Called from newcte

FUNCTION INTER
Determines Temperature-dependent Properties at Temperature T

FUNCTION FUNCINTER(T1, T2, VAR1, VAR2, T)
Computes Linear Interpolation

SUBROUTINE DEVIATS
Compute Deviatoric Stress

FUNCTION CDEFF5(J)
Compute the effective stress with backstress

SUBROUTINE LUDCMP
Compute Lower Decomposition of a matrix

SUBROUTINE LUBKSB
Solves A*X=B

SECTION 6
THEORETICAL BACKGROUND

Thermoviscoplastic micromechanical modeling of metal matrix composites consists of two problems: a boundary value problem in terms of stresses in an idealized geometry, and an initial value problem for marching through time to determine the internal state variables after incremental changes in the thermal and mechanical loading conditions. Three micromechanical geometries are described in section 6.1. These geometries are a) the concentric cylinder geometry (CCM) that yields a three-dimensional state of stress around the fiber in a unidirectional composite, b) CCM with a parallel element representing the [90] ply, and c) a uniaxial stress model in which the fiber/matrix acts in parallel with a fiber/matrix/[90] or any other layup characterized by average axial stresses and strains in each component. In the case of the first two models that use the CCM, finite difference techniques are used to solve for the stress-strain distribution by estimating the plastic strain increments. The constitutive models used to describe the mechanical behavior of each component in the above geometries can be chosen from elastic, bilinear elastic-plastic, Bodner-Partom with backstress, Bodner-Partom with directional hardening, and Bodner-Partom with directional hardening and damage options in the program. The relevant equations for these constitutive models are summarized in section 6.2. These constitutive models are numerically integrated for each loading increment to determine the plastic strains and the internal state variables. Two versions of the forward Euler technique used in FIDEP2 code for numerical integration are summarized in section 6.3.

6.1 Micromechanical Models

The formulation of a micromechanical model results in a boundary value problem. The CCM, hybrid CCM with a [90] ply, and a uniaxial stress model subjected to thermal loading and either stress- or strain-controlled loading conditions are discussed below (Fig. 34). The formulation is in terms of total stresses and strains. This allows the use of the same formulation for temperature-dependent material properties as well as isothermal problems without making modifications to account for the change of properties with temperature. For example, in the one-dimensional elastic case, the total stress-strain relationship for both isothermal and nonisothermal cases is s = E(T) e. In incremental form, the variation of the modulus with temperature should be taken into account for the nonisothermal case as follows:

$$d\sigma = E(T)d\varepsilon + \varepsilon\frac{\partial E}{\partial T}dT\,. \qquad (2)$$

In the present formulation, only the constitutive relations for the internal state variables and the plastic strains are in incremental form, since the evolution of these variables is path dependent.

6.1.1 Concentric Cylinder Model

The methodology is presented in Coker, et al., 1993, and is repeated here for completeness sake. A representative volume element of the composite is modeled as concentric cylinders with the core cylinder representing the fiber and the outer ring representing the matrix (Fig. 34). The fiber and matrix radii are denoted as a and b, respectively. The direction of the z-axis is along the fibers, and the cylinders are infinitely long in the axial direction. Cylindrical coordinates are used in the equations.

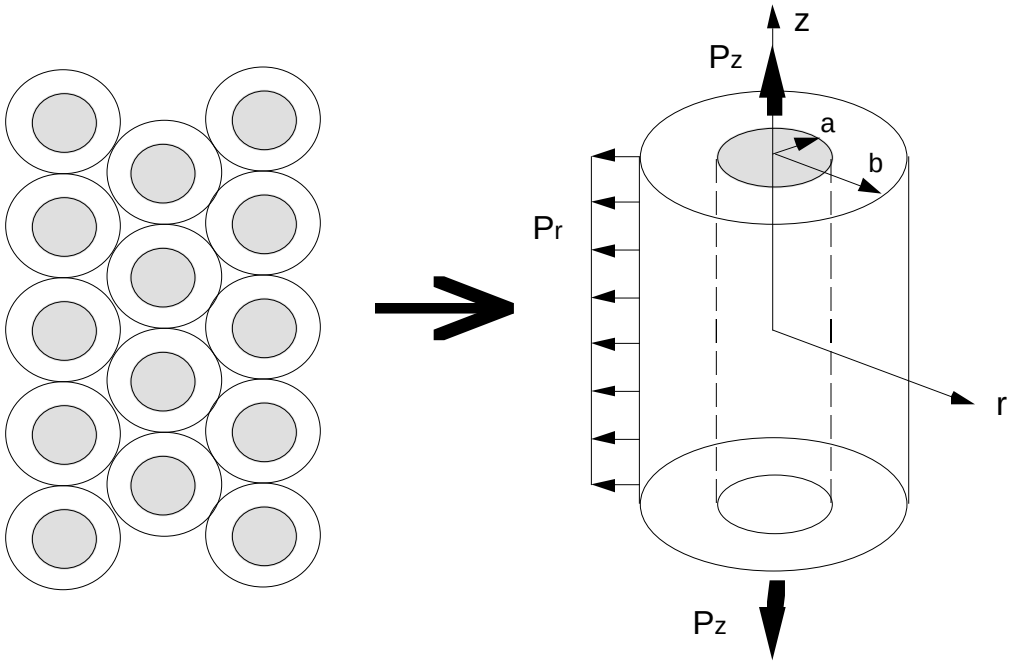


Figure 34. Representative Volume Element (RVE) of a Unidirecitonal Composite Modeled as Concentric Cylinders.

The following assumptions are made in the analysis: the temperature distribution is uniform and is quasi-static; a perfect bond exists between the constituents of the composite so that there is no slippage nor separation of the constituents; the concentric cylinders are in generalized plane strain and are subjected to axisymmetric loadings and displacements so that the shear stresses are zero; and the constituent properties are isotropic and the material is incompressible.

In addition, the following boundary conditions are imposed: a) radial stress is P_r at $r=b$, b) stresses are finite at $r=0$, and c) radial displacements and radial stresses are continuous at the interface.

6.1.1.1 Governing Equations

Equilibrium and compatibility equations in cylindrical coordinates for an axisymmetric generalized plane-strain case simplify to:

$$\frac{d\sigma_r}{dr} + \frac{\sigma_r - \sigma_\theta}{r} = 0, \tag{3}$$

$$\frac{d\varepsilon_\theta}{dr} - \frac{\varepsilon_r - \varepsilon_\theta}{r} = 0, \tag{4}$$

And the stress-strain equations are as follows:

$$\varepsilon_r = \frac{1}{E}(\sigma_r - \nu(\sigma_\theta + \sigma_z)) + \alpha T + \varepsilon_r^p + d\varepsilon_r^p,$$
$$\varepsilon_\theta = \frac{1}{E}(\sigma_\theta - \nu(\sigma_r + \sigma_z)) + \alpha T + \varepsilon_\theta^p + d\varepsilon_\theta^p, \quad (5)$$
$$\varepsilon_z = \frac{1}{E}(\sigma_z - \nu(\sigma_r + \sigma_\theta)) + \alpha T + \varepsilon_z^p + d\varepsilon_z^p,$$

where: ε_r^p, ε_θ^p, and ε_z^p are the total accumulated plastic strains up to, but not including the current increment of loading.

$d\varepsilon_r^p$, $d\varepsilon_\theta^p$, and $d\varepsilon_z^p$ are the plastic strain increments due to the current increment of loading.

ε_r, ε_θ, and ε_z are the total strains.

σ_r, σ_θ, and σ_z are the stresses.

α is the secant coefficient of thermal expansion (CTE).

ν is the Poisson's ratio.

E is the Young's modulus.

T is the change in temperature from a reference state in which the stresses and the strains are assumed to be zero.

Substitution of equation 5 into equation 4 to eliminate total radial and hoop strains yields:

$$\frac{d}{dr}\left(\frac{\sigma_\theta}{E} - \frac{\nu}{E}\left(\sigma_r + \nu(\sigma_r + \sigma_\theta) - \alpha E T + E(\varepsilon_x - \varepsilon_z^p - d\varepsilon_z^p)\right) + \alpha T + \varepsilon_\theta^p + d\varepsilon_\theta^p\right)$$
$$+ \frac{(1+\nu)}{Er}(\sigma_\theta - \sigma_r) + \frac{\varepsilon_\theta^p + d\varepsilon_\theta^p - \varepsilon_r^p - d\varepsilon_r^p}{r} = 0. \quad (6)$$

The equations 3 and 6, and the boundary conditions define the boundary value problem for the two unknowns σ_r and σ_θ. The axial strain, ε_z, is a constant value across the cross section due to the imposed generalized plane-strain condition and will be determined next.

6.1.1.2 Computation of Axial Strain

To compute the axial strain, the stress-strain equation in the axial direction (eqn. 5) is multiplied by r and integrated over the cross section:

$$\varepsilon_z \int_0^b Er\,dr = \int_0^b \sigma_z r\,dr - \int_0^b \nu(\sigma_r + \sigma_\theta) r\,dr + \int_0^b \alpha E T r\,dr + \int_0^b E(\varepsilon_z^p + d\varepsilon_z^p) r\,dr. \quad (7)$$

For k concentric cylinders, let a_i be the outer radius of the ith ring and $a_o = 0$, then the integral on the left hand side reduces to:

$$\varepsilon_z \int_0^b Er\,dr = \varepsilon_z \sum_{i=1}^{k} \frac{E_i}{2}(a_i^2 - a_{i-1}^2). \quad (8)$$

The first integral on the right side is evaluated using the global equilibrium equation in the axial direction; i. e., internal forces are equal to the external applied forces:

$$\int_0^b \sigma_z(2\pi r)dr = P_z(\pi r^2), \tag{9}$$

where P_z is the applied axial stress.

Rearranging the terms, the equilibrium equation (eqn. 3) can also be written as:

$$(\sigma_r + \sigma_\theta)r = \frac{d}{dr}(r^2\sigma_r). \tag{10}$$

Using equation 10, the second integral on the right side of equation 7 becomes:

$$\int_0^b \nu \frac{d}{dr}(r^2\sigma_r)dr = \sum_{i=1}^{k} \nu_i(a_i^2\sigma_r(a_i) - a_{i-1}^2\sigma_r(a_{i-1})). \tag{11}$$

Expanding and recollecting terms in equation 11:

$$\int_0^b \nu \frac{d}{dr}(r^2\sigma_r)dr = \sum_{i=1}^{k-1}(\nu_i - \nu_{i-1})a_i^2\sigma_r(a_i) + \nu_k b^2\sigma_r(b), \tag{12}$$

where $\sigma_r(b)$ is the applied radial stress at $r=b$.

The remaining terms are similarly evaluated assuming constant material properties and temperature distribution in each cylinder. The axial strain for k concentric cylinders then becomes:

$$\varepsilon_z = \frac{1}{E_c}\left(P_z - 2\sum_{i=1}^{k-1} V_i\sigma_r(a_i)(\nu_i - \nu_{i+1}) - 2\nu_k\sigma_r(b) + \alpha_c E_c T + \frac{2}{b^2}\sum_{i=1}^{k} E_i\left(\int_0^b (\varepsilon_z^p + d\varepsilon_z^p)rdr\right)\right) \tag{13}$$

where $\sigma_r(b) = P_r$ is the applied radial stress at $r=b$

V_i is the volume fraction of the ith cylinder, $V_i = \dfrac{a_i^2 - a_{i-1}^2}{b^2}$

E_c is the axial composite modulus, $E_c = \sum_{i=1}^{k} E_i V_i$

α_c is the axial CTE of the composite, $\alpha_c = \dfrac{1}{E_c}\sum_{i=1}^{k} \alpha_i E_i V_i$.

In equation 13, the axial strain is written in terms of the radial stresses at the interfaces. The total plastic strains are known from the previous loading steps, and the new plastic strain increments are related to the stresses through a flow rule.

Note that for elastic fiber, equal Poisson's ratios for the fiber and matrix and zero applied radial stress, the second and third terms vanish leaving the total axial strain as the sum of the composite elastic strain (ε_z^{ec}), composite thermal strain (ε_z^{thc}) and composite plastic strain (ε_z^{pc}), as shown in the following equation:

$$\varepsilon_z^c = \varepsilon_z^{ec} + \varepsilon_z^{thc} + \varepsilon_z^{pc} = \frac{P_z}{E_c} + \alpha_c T + \frac{2}{b^2}\frac{E_m}{E_c}\int_a^b (\varepsilon_z^p + d\varepsilon_z^p) r dr . \tag{14}$$

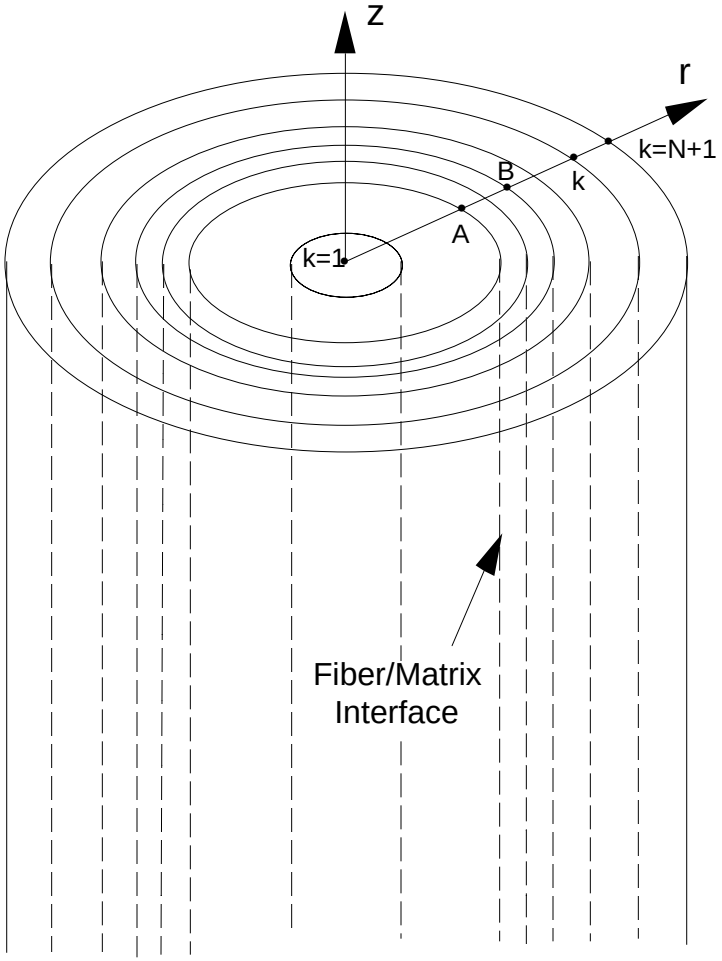
If the plastic strain is constant throughout the matrix, then we have for the total strain:

$$\varepsilon_z^c = \frac{P_z}{E_c} + \alpha_c T + \frac{E_m V_m}{E_c}\varepsilon_z^{pm} \quad , \tag{15}$$

where ε_z^{pm} is the average matrix plastic strain. This expression is the same as that for the uniaxial stress model.

6.1.1.3 Numerical Solution

The method of finite differences is used to solve the two ordinary differential equations [Mendelson, 1968]. The disk radius is divided into N intervals as shown in Figure 35. There are thus *N+1* stations, the first station being at the center of the disk and the last station at the outer



35. Discretization of the CCM.

radius. Eqations. 3 and 6 are written in finite difference form at the midpoints of N cylinders, resulting in 2 N equations as follows:

$$\left.\begin{aligned} &\frac{1}{c_i}\sigma_{r,i-1} - \sigma_{r,i} + a_i\sigma_{\theta,i-1} + a_i\sigma_{\theta,i} = 0 \\ &G_i\sigma_{r,i-1} + D_i\sigma_{r,i} + H_i\sigma_{\theta,i-1} - F_i\sigma_{\theta,i} = Q_i - P_i \end{aligned}\right\} \quad i = 2,...,N+1, \qquad (16)$$

where $a_i = (r_i - r_{i-1})/2r_i$, $b_i = E_i / E_{i-1}$, $c_i = r_i / r_{i-1}$,

and

$$\begin{aligned} D_i &= (1+\nu_i)(\nu_i + a_i), \\ F_i &= (1+\nu_i)(1-\nu_i + a_i), \\ G_i &= b_i(1+\nu_{i-1})(\nu_{i-1} - a_i c_i), \\ H_i &= b_i(1+\nu_{i-1})(1-\nu_{i-1} - a_i c_i), \\ Q_i &= E_i T(\alpha_i(1+\nu_i) - \alpha_{i-1}(1+\nu_{i-1})), \\ P_i &= E_i(P_i^* + \varepsilon_z(\nu_i - \nu_{i-1})), \end{aligned}$$

where

$$P_i^* = \nu_i(\varepsilon_{r,i}^{p+} + \varepsilon_{\theta,i}^{p+}) - \nu_{i-1}(\varepsilon_{r,i-1}^{p+} + \varepsilon_{\theta,i-1}^{p+}) + a_i\left[\varepsilon_{r,i}^{p+} + c_i\varepsilon_{r,i-1}^{p+} - \varepsilon_{\theta,i}^{p+}(1/a_i + 1) + \varepsilon_{\theta,i-1}^{p+}(1/a_i - c_i)\right]$$

and the plastic strains, $\varepsilon_{r,i}^{p+}$, etc., are the updated plastic strains, i. e., $\varepsilon_{r,i}^{p+} = \varepsilon_{r,i}^{p} + d\varepsilon_{r,i}^{p}$, etc. The coefficients at the left side are functions of material properties at the i[th] station. Only the P^* term on the right side involves plastic strains. The unknowns are $\sigma_{r,i}$ and $\sigma_{\theta,i}$, $i = 1,...,N+1$. Using the boundary conditions, $\sigma_{r,n+1} = P_r$ and $\sigma_{\theta 1}$ = the unknowns reduce to $2N$; $\sigma_{r,i}$, $i=1,...,N$, and $\sigma_{\theta i}$, $i=2,...,N+1$. The axial stress distribution, $\sigma_{z,i}$, $i=1,...,N+1$, is given by equation 5.

Moving the radial stress terms in equation 13 to the left side of equation. 16 and letting the radial stress at the j[th] interface correspond to the radial stress at node $i=I_j$, i. e., $\sigma_r(a_j) = \sigma_{r,I_j}$, the second expression in equation 16 becomes:

$$\begin{aligned} &-G_i\sigma_{r,i-1} + D_i\sigma_{r,i} + H_i\sigma_{\theta,i-1} - F_i\sigma_{\theta,i} - 2(\nu_i - \nu_{i-1})\frac{E_i}{E_c}\sum_{j=1}^{k-1} V_j\sigma_{r,I_j}(\nu_{I_j} - \nu_{I_j+1}) \\ &= Q_i - E_i P_i^* - E_i(\nu_i - \nu_{i-1})\varepsilon_z^*, \end{aligned} \qquad (17)$$

where

$$\varepsilon_z^* = \frac{1}{E_c}(P_z - 2\nu_k P_r + \alpha_c E_c T + 2/b^2\sum_{j=1}^{k} E_j\int_0^b \varepsilon_z^{p+} r dr). \qquad (18)$$

In the case of two concentric cylinders, $k=2$ and $j=1$, let INT be defined as the index of the highest numbered node in the fiber and $INT+1$ be the index of the lowest numbered node in the matrix. The fiber/matrix interface lies between these two nodes. Then, for all equations in which $i > INT+1$, i. e., equations for nodes not adjacent to the interface, ν_i-ν_{i-1} is zero and the axial strain vanishes from these equations. For the $INT+1st$ equation, equation 17 reduces to:

$$(2V_f E_m / E_c(\nu_f - \nu_m)^2 - G_{INT+1})\sigma_{r,INT} + D_{INT+1}\sigma_{r,INT+1} + H_{INT+1}\sigma_{\theta,INT} + F_{INT+1}\sigma_{\theta,INT+1}$$
$$= Q_{INT+1} - E_m P^*_{INT+1} - E_m(\nu_m - \nu_f)\varepsilon^*_z. \quad (19)$$

One final step before equation 16 is written in matrix form is to eliminate singular terms for *i=2*. Note that $\sigma_{r,1} = \sigma_{\theta 1}$. Replacing $\sigma_{\theta,1}$ in equation 16 by $\sigma_{r,1}$ we obtain:

$$(1/c_2 + a_2)\sigma_{r,1} - \sigma_{r,2} + a_2\sigma_{\theta,2} = 0 \quad (20)$$

and

$$(H_2 - G_2)\sigma_{r,1} + D_2\sigma_{r,2} - F_2\sigma_{\theta,2} = Q_2 - P_2. \quad (21)$$

In the first equation $1/c_2 = r_1/r_2 = 0$. In the second equation, the term $H_2 - G_2$ is expanded and simplified. The final equations for *i=2* become:

$$a_2\sigma_{r,1} - \sigma_{r,2} + a_2\sigma_{\theta,2} = 0 \quad (22)$$

and

$$(1+\nu_1)(1-2\nu_1)b_2\sigma_{r,1} + D_2\sigma_{r,2} - F_2\sigma_{\theta,2} = Q_2 - P_2 \quad (23)$$

Hence equation 16 is written in matrix form as:

$$\underline{A}\ \underline{x} = \underline{B}, \quad (24)$$

where $\underline{A}$ is a 2N by 2N matrix of constant coefficients, $\underline{x}$ is the radial and hoop stress vector of length 2N, and $\underline{B}$ is a vector of length 2N, as shown in Figure 36. In matrices $\underline{A}$ and $\underline{B}$, all of the constants are known except the plastic strain increments, which are presumed or computed from a flow rule.

$$\underline{A}\underline{x} = \underline{b}$$

$\underline{A}$= Matrix of material properties, $\underline{x} = \begin{bmatrix} \underline{\sigma}_r \\ \underline{\sigma}_\theta \end{bmatrix}$, $\underline{b} = \begin{bmatrix} \underline{0} \\ \underline{Q} - \underline{P}(\underline{\Delta\varepsilon}_{ij}) \end{bmatrix}$

a_2	-1	0	0	...	0	0	a_2	0	0	...	0	0	0	$\sigma_{r,1}$		0
0	$1/c_3$	-1	0	...	0	0	a_3	a_3	0	...	0	0	0	$\sigma_{r,2}$		0
0	0	$1/c_4$	-1	...	0	0	0	a_4	a_4	...	0	0	0			
0	0	0	0	...	$1/c_N$	-1	0	0	0	...	a_N	a_N	0	$\sigma_{r,N-1}$		0
0	0	0	0	...	0	$1/c_{N+1}$	0	0	0	...	0	a_{N+1}	a_{N+1}	$\sigma_{r,N}$	=	$\sigma_{r,b}$
H_2-G_2	D_2	0	0	...	0	0	$-F_2$	0	0	...	0	0	0	$\sigma_{\theta,2}$		Q_2-P_2
0	$-G_3$	D_3	0	...	0	0	H_3	$-F_3$	0	...	0	0	0	$\sigma_{\theta,3}$		Q_3-P_3
		...	G^*	...												
0	0	0	0	...	$-G_N$	D_N	0	0	0	...	H_N	$-F_N$	0	$\sigma_{\theta,N}$		Q_N-P_N
0	0	0	0	...	0	$-G_{N+1}$	0	0	0	...	0	H_{N+1}	$-F_{N+1}$	$\sigma_{\theta,N+1}$		Q_{N+1} - $P_{N+1}\sigma_{r,b}$

$$G^* = A(N + INT, INT) = 2V_f(\nu_f - \nu_m)^2 E_m / E_c - G_{INT+1}$$

Figure 36. The Linear System of Equations Resulting from the Finite Differences Formulation of the Concentric Cylinder Model.

6.1.2 Hybrid [0/90] Model

The [0/90] layup is treated by adding a parallel element with smeared [90] ply properties to the [0] ply represented by the concentric cylinder model (CCM) as shown in Figire 37 [Coker, et al., 1993b]. Stress equilibrium and strain compatibility are satisfied in the axial direction. No coupling of the transverse strains is assumed between the plies. There is no applied radial stress. The [90] lamina is characterized as a one-dimensional, homogeneous and isotropic element. The smeared mechanical and thermal properties for the [90] ply are obtained from a 3-D finite element analysis of a unit-cell or experiments.

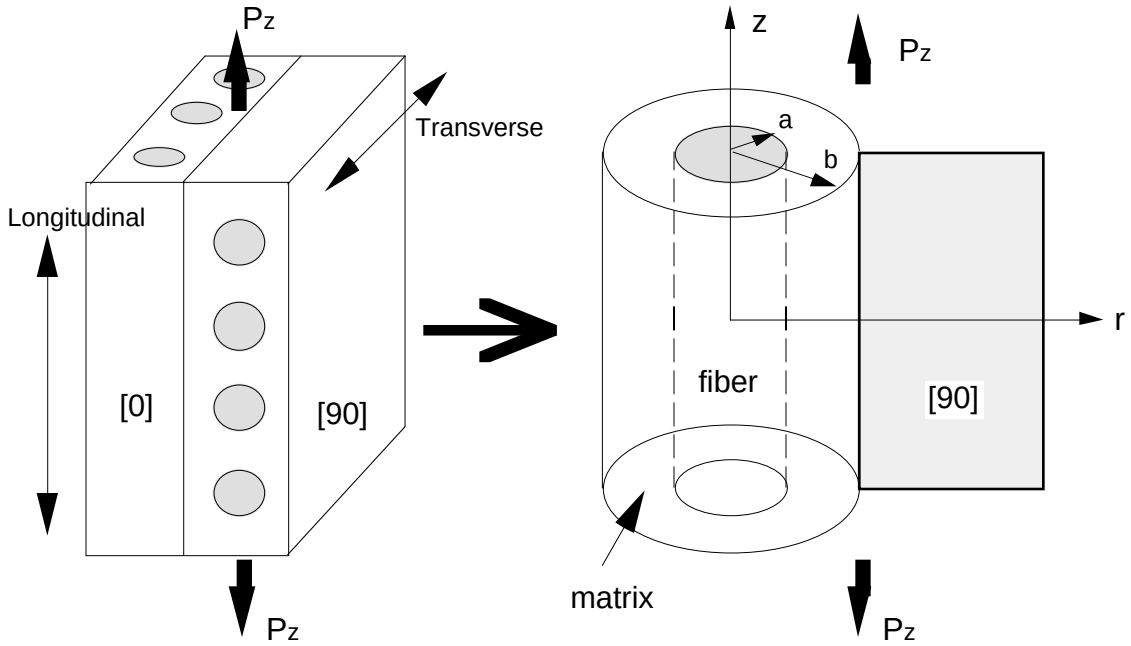


Figure 37. [0/90] Laminate and Its Representation as a CCM with a Parallel [90] Element.

The equations for the radial and hoop stresses for the CCM remain the same. The [90] element does not influence the transverse stresses in the CCM except through the effect on the axial strain and stress. Accounting for the parallel [90] element, the equation for the axial strain (eqn. 13) becomes:

$$\varepsilon_z = \frac{1}{E_c}\left\{P_z - 2\sum_{i=1}^{k-2} V_i \sigma_r(a_i)(\nu_i - \nu_{i+1}) + \alpha_c E_c T + \frac{2}{b^2}\sum_{i=1}^{k-1} E_i \int_0^b \varepsilon_z^p r dr + V_{90} E_{90} \varepsilon_{z,90}^p\right\}. \quad (25)$$

First, the radial and hoop stressses in the [0] ply are obtained from equation 24. The axial stresses in the [0] ply is then obtained from equation 5. Finally, the axial aggregate stress in the [90] ply is obtained from:

$$\sigma_{90} = \frac{1}{V_{90}}\left(P_z - \sigma_f V_f - \frac{V_m}{b^2 - a^2}\int \sigma_m r dr\right). \quad (26)$$

The smeared properties for the [90] ply are computed from finite element analysis of tensile loading at several temperatures. The effective transverse CTE is obtained from the aggregate strain versus temperature plot during cool-down and a database is created for the effective [90] ply properties at several temperatures and strain rates. The [90] ply is defined by a constitutive model which, in this study, is a Bodner-Partom model with directional hardening and damage, described in Section 6.2.4. The constitutive model of the [90] ply accounts for viscoplastic matrix behavior and damage in the form of fiber/matrix separation. The analysis accounts for the residual thermal stresses due to the CTE mismatch between the fiber and the matrix, as well as between the [0] ply and the [90] ply that occur during consolidation of the laminate. The [0/90] model utilizes the efficiency and simplicity of the CCM as incorporated into the computer program FIDEP2.

6.1.3 Uniaxial Stress Model

The uniaxial stress model (USM) is a rule of mixtures model consisting of multiple parallel elements that can represent constituents such as the fiber, matrix, and [90] ply constraining each other in the axial direction (Fig.ure 1(c)). For the USM, the constituent strain is equal to the composite strain:

$$\varepsilon_i = \varepsilon_c \,,\ i=f,\ m,\ 90 \tag{27}$$

where f is the fiber, m is the matrix and c is the composite. The stress-strain relations are:

$$\sigma_i = E_i(\varepsilon_c - \varepsilon_i^{th} - \varepsilon_i^p) \,,\ i = f,\ m,\ 90 \tag{28}$$

where ε_i^{th} is the thermal strain and ε_i^p is the inelastic strain. Load equilibrium in the axial direction is:

$$\sigma_{app} = \sum \sigma_i V_i \,,\ i=f,\ m,\ 90. \tag{29}$$

From these equations the expression for total strain becomes:

$$\varepsilon_c = \frac{1}{E_c}(\sigma_{app} + \alpha_c E_c \Delta T + \sum E_i V_i \varepsilon_i^p). \tag{30}$$

The stresses in the constituents are then obtained from equation 28. The CCM yields a three-dimensional stress distribution around the fiber, whereas the USM considers only the axial stresses in the constituents.

6.2 Constitutive Models

The plastic strain rates or plastic strain increments at the next incremental load is obtained by the solution of an initial value problem. The plastic strain rates and other internal state variables are given by the constitutive models and are obtained by numerical integration of the respective evolution equations. First, the general formulation that yields the relationship between the stresses and the plastic strains is described. The following sections then describe the different

constitutive models and their formulation of the evolution of plastic strain rates and the internal state variables with time. The constitutive models that have been incorporated into FIDEP2 are: elastic-plastic, Bodner-Partom with backstress, Bodner-Partom with directional hardening, and Bodner-Partom with damage.

6.2.1 General Formulation

The total strain can be divided into its elastic, plastic and thermal components:

$$\varepsilon_{ij} = \varepsilon_{ij}^{e} + \varepsilon_{ij}^{p} + \varepsilon_{ij}^{th} . \tag{31}$$

The inelastic strain, ε_{ij}^{p}, is equal to the plastic strain in the case of elastic-plastic material. In the case of viscoplastic behavior, the unified theory such as Bodner-Partom, this term represents plastic flow, creep, and stress relaxation. The elastic strain is given by Hooke's law:

$$\varepsilon_{ij}^{e} = \frac{S_{ij}}{2G} . \tag{32}$$

The thermal strain is given by:

$$\varepsilon_{ij}^{th} = \alpha \Delta T . \tag{33}$$

The plastic strain can be written as a plastic strain increment plus the plastic strain from the old time step:

$$\varepsilon_{ij}^{p} = \varepsilon_{ij,old}^{p} + d\varepsilon_{ij}^{p} . \tag{34}$$

It may also be written in terms of inelastic strain rate as:

$$\varepsilon_{ij}^{p} = \varepsilon_{ij,old}^{p} + \dot{\varepsilon}_{ij}^{p} \Delta\tau . \tag{35}$$

Flow rules define the relationship between the inelastic strain rates and the stresses. A common flow rule is the Prandtl-Reuss flow rule in which the plastic strain is assumed to be parallel to the deviatoric stresses:

$$\dot{\varepsilon}_{ij}^{p} = \lambda_1 S_{ij} , \qquad \dot{\varepsilon}_{kk}^{p} = 0 . \tag{36}$$

This flow rule is used by both classical plasticity and Bodner-Partom with directional hardening models. The Bodner-Partom with backstress model assumes the plastic strain rate to be parallel to deviatoric stress minus a backstress or equilibrium stress:

$$\dot{\varepsilon}_{ij}^{p} = \lambda_1 (S_{ij} - \Omega_{ij}) , \qquad \dot{\varepsilon}_{kk}^{p} = 0 , \tag{37}$$

where Ω_{ij} is the backstress.

Kinetic equations are obtained by squaring both sides of the above equations:

$$\lambda = \left(\frac{D_2^p}{J_2} \right)^{1/2}, \tag{38}$$

where D_2^p is the second invariant of the plastic strain rate, $D_2^p = \frac{1}{2}\varepsilon_{ij}^p \varepsilon_{ij}^p$, and J_2 is the second invariant of the deviatoric stress, $J_2 = \frac{1}{2} S_{ij} S_{ij}$. For the Bodner-Partom with backstress model, $J_2 = \frac{1}{2}(S_{ij} - \Omega_{ij})(S_{ij} - \Omega_{ij})$. We define effective plastic strain increment and effective stress, respectively, as:

$$d\varepsilon^p = \sqrt{\frac{2}{3} d\varepsilon_{ij}^p d\varepsilon_{ij}^p} \quad \text{and} \quad \sigma_{eff} = \sqrt{\frac{3}{2} S_{ij} S_{ij}}. \tag{39}$$

Then in terms of effective quantities,

$$\lambda = \frac{3}{2} \frac{d\varepsilon^p}{\sigma_{eff}}, \tag{40}$$

and the flow rule becomes,

$$d\varepsilon_{ij}^p = \frac{3}{2} \frac{d\varepsilon^p}{\sigma_{eff}} S_{ij}. \tag{41}$$

These effective quantities are equal to the stress and plastic strain increment in the case of a uniaxial tension test.

6.2.2 Bilinear Elastic-Plastic Model

For an elastic-plastic material, equations 39 and 41 are used together with the von Mises yield criterion. Yielding begins when the effective stress reaches the yield stress determined from a uniaxial tensile test. The yield stress for a bilinear stress strain curve, with a plastic modulus E_p and elastic modulus E is given by:

$$Y = \sigma_y + \frac{mE}{1-m} \varepsilon_p^{eff}, \tag{42}$$

where m is the ratio of the plastic modulus to the elastic modulus, and ε_p^{eff} is the integral of the effective plastic strain increment.

The Prandtl-Reuss relations (eqn. 41) relate the plastic strain increments to the stresses. Another method for computing the plastic strain increments is to use equations that relate the plastic strain increments to the modified total strains. These equations are more stable with respect to the loading increment size and converge faster for most loading cases. In this approach the plastic strain increments are computed using a modified Prandtl-Reuss relations as discussed below [Mendelson, 1968].

Assume a loading path to a given state of stress and total plastic strains ε_{ij}^{p} and let the next load step be applied producing additional plastic strains $\Delta\varepsilon_{ij}^{p}$. The total strains can be written as:

$$\varepsilon_{ij} = \varepsilon_{ij}^{e} + \varepsilon_{ij}^{th} + \varepsilon_{ij,old}^{p} + \Delta\varepsilon_{ij}^{p}, \tag{43}$$

where ε_{ij}^{e} is the elastic component of the total strain, ε_{ij}^{th} is the thermal strain, ε_{ij}^{p} is the accumulated plastic strain up to (but not including) the current increment of load, and $\Delta\varepsilon_{ij}^{p}$ is the increment of plastic strain due to the increment of load. The previous plastic strains ε_{ij}^{p} are presumed to be known, and $\Delta\varepsilon_{ij}^{p}$ is to be calculated.

The modified total strains are defined as:

$$\varepsilon'_{ij} = \varepsilon_{ij} - \varepsilon_{ij,old}^{p} = \varepsilon_{ij}^{e} + \varepsilon_{ij}^{th} + \Delta\varepsilon_{ij}^{p}. \tag{44}$$

The deviatoric strains are obtained by subtracting the mean strain from the diagonal component of both sides:

$$\varepsilon'_{ij} = \varepsilon_{ij}^{e} + \Delta\varepsilon_{ij}^{p}, \tag{45}$$

where ε_{ij}^{e} is the elastic strain deviator tensor and ε'_{ij} is the modified strain deviator tensor. From Hooke's Law and Prandtl-Reuss equation (eqn. 41):

$$\varepsilon_{ij}^{e} = \frac{S_{ij}}{2G} = \frac{\Delta\varepsilon_{ij}^{p}}{2G\lambda}, \tag{46}$$

where G is the shear modulus. Using this expression and equation 41, equation 45 becomes:

$$\varepsilon'_{ij} = (1 + \frac{1}{2G\lambda}) d\varepsilon_{ij}^{p}. \tag{47}$$

Multiplying both sides of the equation by two thirds itself yeilds:

$$\frac{2}{3}\varepsilon'_{ij}\,\varepsilon'_{ij} = \frac{2}{3}(1 + \frac{1}{2G\lambda})^{2} d\varepsilon_{ij}^{p} d\varepsilon_{ij}^{p}. \tag{48}$$

We define effective modified total strain in a similar fashion to the effective incremental plastic strain rate to obtain:

$$\varepsilon'_{eff} = (1 + \frac{1}{2G\lambda}) d\varepsilon^{p}. \tag{49}$$

The modified Prandtl-Reuss relations then become:

$$d\varepsilon_{ij}^{p} = \frac{d\varepsilon^{p}}{\varepsilon'_{eff}} \varepsilon'_{ij}, \tag{50}$$

where ε'_{ij} are the modified total deviatoric strains, ε'_{eff} is the equivalent or effective modified total strain defined by:

$$\varepsilon'_{eff} = \sqrt{\frac{2}{3}\varepsilon'_{ij}\,\varepsilon'_{ij}}\,, \tag{51}$$

and $d\varepsilon^p$ is the equivalent or effective plastic strain increment defined by equation 39. The modified Prandtl-Reuss equations are:

$$d\varepsilon_x^p = \frac{d\varepsilon^p}{3\varepsilon'_{eff}}(2\varepsilon'_x - \varepsilon'_y - \varepsilon'_z),$$

$$d\varepsilon_y^p = \frac{d\varepsilon^p}{3\varepsilon'_{eff}}(2\varepsilon'_y - \varepsilon'_x - \varepsilon'_z), \tag{52}$$

and

$$d\varepsilon_z^p = -(d\varepsilon_x^p + d\varepsilon_y^p).$$

Equation 50 is equivalent to the Prandtl-Reuss equation 41, but relate the incremental plastic strains to modified total strains instead of the stresses.

The relationship between the effective incremental plastic strain and effective modified total strain is obtained by substituting λ from equation 40 in equation 49:

$$\varepsilon'_{eff} = d\varepsilon^p + \frac{1}{3G}\sigma_{eff}\,. \tag{53}$$

Let the effective stress from the previous loading step be $\sigma_{eff,i-1}$. By expanding the effective stress in a Taylor series about $\sigma_{eff,i-1}$:

$$\sigma_{eff} = \sigma_{eff,i-1} + \left(\frac{d\sigma_{eff}}{d\varepsilon^p}\right)_{i-1} d\varepsilon^p, \tag{54}$$

the effective stress is eliminated from equation 4341 to obtain:

$$d\varepsilon^p = \left(\varepsilon'_{eff} - \frac{1}{3G}\sigma_{eff,i-1}\right)\frac{1}{1+\frac{1}{3G}\left(d\sigma_{eff}\,/\,d\varepsilon^p\right)_{i-1}}. \tag{55}$$

Equations 50, 51, and 55 are used simultaneously to determine plastic strain increments at each loading step for a bilinear elastic-plastic material.

6.2.3 Bodner-Partom Model with Backstress

The Bodner-Partom with backstress model is a modified version of the Bodner-Partom model [Bodner and Partom, 1975] in which backstress is included to account for both isotropic and

kinematic hardening behavior [Ramaswamy, et al., 1990]. The effective plastic strain rate is defined by:

$$\dot{\varepsilon}^p = \frac{2}{\sqrt{3}} D_o \exp\left(-\frac{1}{2}\left(\frac{Z^2}{3K_2} \right)^n \right), \tag{56}$$

where $K_2 = \frac{1}{2}(S_{ij} - \Omega_{ij})(S_{ij} - \Omega_{ij})$. The backstress evolution equation is represented by:

$$\dot{\Omega}_{ij} = \frac{2}{3} f_1 \dot{\varepsilon}^I_{ij} - f_1 \frac{\Omega_{ij}}{\Omega_s} \dot{\varepsilon}^I_{eff} + f_2 \dot{S}_{ij}, \tag{57}$$

where Ω_s is the saturation value of the backstress during creep loading. The saturation of the backstress is given by the relation:

$$\dot{\Omega}_s = -B\left(\frac{\sqrt{3J_2}}{\sigma_o} \right)(\Omega_s - \Omega_{crp}). \tag{58}$$

The drag-stress evolution equation is given by:

$$\dot{Z} = m\dot{W}_p(Z_1 - Z) - A_1(Z - Z_2)^p, \tag{59}$$

where $\dot{W}_p$ is the rate of inelastic work, given by, $\dot{W}_p = \sigma_{ij}\dot{\varepsilon}^p_{ij}$.

6.2.4 Bodner-Partom Model with Directional Hardening

The effective plastic strain rate is defined by:

$$\dot{\varepsilon}^p = \frac{2}{\sqrt{3}} D_o \exp\left(-\frac{1}{2}\left(\frac{(Z_I + Z_D)^2}{3K_2} \right)^n \right), \tag{60}$$

where Z_I and Z_D represent the isotropic and directional hardening components, respectively. [Chan, et al., 1988; Chan et al., 1990]. The isotropic hardening evolution equation is given by:

$$\dot{Z}_I = m_1\dot{W}_p(Z_1 - Z_I) - A_1 Z_1\left(\frac{Z_I - Z_2}{Z_1} \right)^p + \dot{T}\left[\left(\frac{Z_I - Z_2}{Z_1 - Z_2} \right)\frac{\partial Z_1}{\partial T} + \left(\frac{Z_1 - Z_I}{Z_1 - Z_2} \right)\frac{\partial Z_2}{\partial T} \right] \tag{61}$$

The directional hardening is given by:

$$Z_D = \beta_{ij} u_{ij}, \tag{62}$$

where the evolution equation for b_{ij} is given by:

$$\dot{\beta}_{ij} = m_2 \dot{W}_p (Z_3 u_{ij} - \beta_{ij}) - A_2 Z_1 \frac{\beta_{ij}}{\sqrt{\beta_{kl}\beta_{kl}}} \left(\frac{\sqrt{\beta_{kl}\beta_{kl}}}{Z_1} \right)^{r_2} + \dot{T} \frac{\beta_{ij}}{Z_3} \frac{\partial Z_3}{\partial T}, \qquad (63)$$

where $u_{ij} = \frac{\sigma_{ij}}{\sqrt{\sigma_{kl}\sigma_{kl}}}$. The constants used in this model for Timetal21S are determined by trial and error using Mathematica“ from experiments [Neu, 1993].

6.2.5 Bodner-Partom Model with Directional Hardening and Damage

The model discussed in section 6.2.4 was modified to account for fiber/matrix separation by adding a damage parameter [Neu et al., 1996]. This model uses the uniaxial version of the previous equations except that the stress is replaced by an equivalent stress defined by:

$$\tilde{\sigma} = \frac{\sigma}{1 - \eta D} \qquad (64)$$

This effective stress is used in the constitutive relations, which include the isotropic and directional hardening components. The elastic component becomes:

$$\tilde{\sigma} = E(\varepsilon - \varepsilon^p - \varepsilon^{th}). \qquad (65)$$

This is equivalent to the modulus degradation identified by the following:

$$\tilde{E} = E(1 - \eta D). \qquad (66)$$

The evolution equation for damage is given by,:

$$\frac{D}{D^*} = 1 - \exp\left[-\left(\frac{\sigma - \sigma_m - \sigma_{ch}}{\theta} \right)^m \right]. \qquad (67)$$

This evolution equation is updated whenever $\sigma - \sigma_m - \sigma_{ch} > \sigma_p$, where σ_p is the peak stress reached in the [90] ply. The evolution of the internal state variables and the plastic strains are described by the same equations used in Section 6.2.4.

6.3 NUMERICAL INTEGRATION

Two iterative algorithms were considered for this investigation both of which use a forward-Euler integration scheme. The first algorithm uses the Prandtl-Reuss relations. For an increment of load, a distribution is assumed for the plastic strain increments. The boundary value problem is then solved for a first elastic approximation to the stresses and strains. At the same time, the effective plastic strain increment is calculated and the effective stress is computed. Finally, a new estimate is computed for the plastic strain increments and these steps are repeated until convergence is obtained. This algorithm is not very stable and may not converge for large load increments. For nonconvergent cases, the time increments can be taken smaller and smaller until convergence is obtained.

A second iterative method was used for the elastic-plastic material in which the modified version of the Prandtl-Reuss or the plastic strain-total strain relations are used [Mendelson, 1968]. This method is also called the elastic-predictor radial corrector method. In this algorithm, total strains are obtained from the stresses from equation 16 with assumed or previously calculated plastic strain increment estimates. Modified total strains and effective total strain are obtained from equation 49 and stress-strain curve using equation 56. The new plastic strain increments are then determined from equation 51. This process is repeated until convergence of the plastic strains is obtained. This method converges for even large loading increments and converges very rapidly.

Both of these algorithms are implemented into the program FIDEP2, Finite-Difference Code for Elastic-Viscoplastic Analysis of Composites. For the viscoplastic model, the program uses the first algorithm, whereas for an elastic-plastic material, the code uses the second algorithm.

REFERENCES

Bodner, S. R. and Partom, Y., 1975, "Constitutive Equations for Elastic-Viscoplastic Strain Hardening Materials," ASME Journal of Applied Mechanics, Vol. 242, p. 385.

Chan, K. S., Bodner, S. R., and Lindholm, U. S., 1988, "Phenomenological Modeling of Hardening and Thermal Recovery in Metals," ASME Journal of Engineering Materials and Technology, Vol. 110, pp. 1-8.

Chan, K. S., Lindholm, U. S., Bodner, S. R., and Nagy, A., 1990, "High Temperature Inelastic Deformation of the B1900+Hf Alloy under Multiaxial Loading Theory and Experiment," ASME Journal of Engineering Materials and Technology, Vol. 112, January, pp. 7-14.

Coker, D. and Ashbaugh, N. E., 1992, Elastic-Plastic Finite Difference Analysis of Unidirectional Composites Subjected to Thermomechanical Cyclic Loading, WL-TR-93-4043, Wright-Patterson AFB, Materials Directorate, Wright Laboratory.

Coker, D., Ashbaugh, N. E., and Nicholas, T., 1993a, "Analysis of Thermomechanical Cyclic Behavior of Unidirectional Metal Matrix Composites," Thermomechanical Fatigue Behavior of Materials, ASTM STP 1186, Ed. H. Sehitoglu, American Society of Testing and Materials, Philadelphia, pp. 50-69.

Coker, D., Ashbaugh, N. E., and Nicholas, T., 1993b, "Analysis of the Thermomechanical Behavior of [0] and [0/90] SCS-6/Timetal21S Composites," Thermomechanical Behavior of Advanced Structural Materials, AD-Vol 34/AMD-Vol. 173, Ed. W. F. Jones, The American Society of Mechanical Engineers, pp. 1-16.

Kroupa, J.L., 1995, "Implementation of a Nonisothermal Unified Inelastic-Strain Theory for a Ti Alloy in ABAQUS5.4 - USER GUIDE, Accepted as an Air Force Technical Manual, AFRL-ML-WP-TR-1998-4143, May 1996.

Mendelson, A., 1968, Plasticity: Theory and Application, MacMillan, New York.

Neu, R. W., 1993, "Nonisothermal Material Properties for the Bodner-Partom Model," MD-Vol. 43/AMD-Vol. 168, L. A. Bertram, S. B. Brown, and A. D. Freed, Eds., Material Parameter Estimation for Modern Constitutive Equations, The American Society of Mechanical Engineers, New York, pp. 211-226.

Neu, R. W., Coker, D., and Nicholas, T., 1996, Cyclic Behavior of Unidirectional and Crossply Titanium Matrix Composites, International Journal of Plasticity, 12, pp. 361-385.

Ramaswamy, V. G., Stouffer, D. C., and Laflen, J. H., 1990, "A Unified Constitutive Model for the Inelastic Uniaxial Response of Rene 80 at Temperatures between 538° C and 982° C," ASME Journal of Engineering Materials and Technology, Vol. 112, No. 3, pp. 280-286.

Sherwood, J.A., and Quimby H.M., 1995, "Micromechanical Modeling of Damage Growth in Titanium Based Metal-Matrix Composites, Computers and Structures, Vol. 56, No. 2/3, pp.505-514.

This page intentionally left blank

APPENDIX A

Material Database File: MATERIAL.DAT

Summary of Material Properties and Types in material data file MATERIAL.DAT

Material no.	Material Model	Material Definition
1	1	SCS-6 Fiber (1), Temperature-independent, n = 0.3
2	1	SCS-6 Fiber (2), Temperature-dependent, n = 0.3
3	1	SCS-6 Fiber (3), Temperature-dependent, n = 0.22
4	2	Ti-24-11 bilinear elastic-plastic, temperature-independent
5	2	Ti-24-11 bilinear elastic-plastic
6	1	Ti-24-11 elastic matrix
7	5	Ti-24-11 Bodner-Partom with backstress
8	5	Ti-24-11 Bodner-Partom with backstress, temperature-independent
9	2	TIMETAL21S bilinear elastic-plastic/UDRI/Strain controlled/ edot=833.3E-6
10	2	TIMETAL21S bilinear elastic-plastic/Round Robin/Stress controlled
11	2	[0¡] 35% SCS-6/Ti-24-11 ply bilinear elastic-plastic
12	2	[90¡] 35% SCS-6/Ti-24-11 ply bilinear elastic-plastic
13	1	SCS-6 Fiber/Steve Johnson, NASA, LaRC, CTE/UDRI/GE Tref = 1010
14	1	SCS-6 Fiber/R. W. Neu/ same as 13 except Tref=900
15	2	[90¡] 35% SCS-6/TIMETAL21S bilinear elastic-plastic/no bonding
16	6	TIMETAL21S Bodner-Partom with Directional Hardening with A1 given as a function
17	6	TIMETAL21S Bodner-Partom with Directional Hardening with A1, CTE, and E given as a function
18	2	TIMETAL21S bilinear elastic-plastic/strain-controlled/ edot = 8.33e-6
19	2	[90] SCS6/TIMETAL21S weak f/m interface edot=833e-6 / Ref: Kroupa Report, 1994
20	2	[90] SCS6/TIMETAL21S weak f/m interface edot=8.33e-6 / Ref: Kroupa Report, 1994

```
 MATERIAL PROPERTIES DATA FILE: MATERIAL.DAT
 =====================================================
 1 1
 SCS-6 FIBER (1), temp indep props, n = 0.3
 1
 T(C) E(GPa) NU     CTE(1E-6/C)
 20   414    0.3   4.703
 20
-----------------------------------------------------
 2 1
 SCS-6 FIBER (2), temp dep props, n = 0.3
 11
 T(C) E(GPa) NU     CTE(1E-6/C)
 20   414    0.30   4.703
 93   414    0.30   4.812
 204  414    0.30   4.970
 316  414    0.30   5.119
 427  414    0.30   5.256
 538  414    0.30   5.382
 649  414    0.30   5.497
 760  414    0.30   5.602
 871  414    0.30   5.697
 982  414    0.30   5.781
 1010 414    0.30   5.800
 1010
-----------------------------------------------------
 3 1
 SCS-6 FIBER (3), temp dep props, n = 0.22
 11
 T(C) E(GPa) NU     CTE(1E-6/C)
 20   414    0.22   4.703
 93   414    0.22   4.812
 204  414    0.22   4.970
 316  414    0.22   5.119
 427  414    0.22   5.256
```

```
 538  414    0.22   5.382
 649  414    0.22   5.497
 760  414    0.22   5.602
 871  414    0.22   5.697
 982  414    0.22   5.781
 1010 414    0.22   5.800
 1010
-------------------------------------------------------
 4 2
 TI-24-11 bilinear elastic-plastic matrix, temp indep
 1
 T(C) E(GPa) NU     CTE(1E-6/C)
 20    94.0  0.3    11.310
 20
 1
 1 2
 SY(MPa)  EP(GPa)
 604.0    1.300
-------------------------------------------------------
 5 2
 Ti-24-11 bilinear elastic-plastic matrix
 11
 T(C) E(GPa) NU     CTE(1E-6/C)
 20    94.0  0.3    11.310
 93    92.0  0.3    11.480
 204   91.0  0.3    11.690
 316   89.0  0.3    11.880
 427   79.0  0.3    12.096
 538   70.0  0.3    12.365
 649   49.5  0.3    12.727
 760   24.5  0.3    13.217
 871   18.0  0.3    13.870
 982   15.9  0.3    14.720
 1010  15.0  0.3    14.972
 1010
 1
```

```
 11 2
 T(C)  SY(MPa)  EP(GPa)
 20    604.0    1.300
 93    560.0    0.900
 204   498.0    0.719
 316   447.0    0.692
 427   421.0    0.415
 538   381.0    0.110
 649   356.5    0.000
 760   252.4    2.350
 871   138.3    2.628
 982   38.04    1.180
 1010  30.00    1.000
-------------------------------------------------------
 6 1
 TI-24-11 elastic matrix
 11
 T(C) E(GPa) NU     CTE(1E-6/C)
 20    94.0  0.3    11.310
 93    92.0  0.3    11.480
 204   91.0  0.3    11.690
 316   89.0  0.3    11.880
 427   79.0  0.3    12.096
 538   70.0  0.3    12.365
 649   49.5  0.3    12.727
 760   24.5  0.3    13.217
 871   18.0  0.3    13.870
 982   15.9  0.3    14.720
 1010  15.0  0.3    14.972
 1010
-------------------------------------------------------
 7 5
 TI-24-11 BODNER-PARTOM WITH BACKSTRESS
 11
 T(C) E(GPa) NU     CTE(1E-6/C)
 20    94.0  0.3    11.310
```

```
93    92.0  0.3    11.480
204   91.0  0.3    11.690
316   89.0  0.3    11.880
427   79.0  0.3    12.096
538   70.0  0.3    12.365
649   49.5  0.3    12.727
760   24.5  0.3    13.217
871   18.95  0.3    13.870
982   15.9  0.3    14.720
1010  15.0  0.3    14.972
1010
2
11 5
T(C)    n       Zo(MPa)    f1(MPa)   f3   BSMAX(MPa)
20.0    1.300   484.       144375.   0.7926  476
93.0    1.300   484.       65317.    0.7800  435
204.0   1.250   491.       36437.    0.7665  377
316.0   1.120   517.       55000.    0.7740  341
427.0   1.000   551.       68750.    0.7680  327
538.0   0.870   970.       78375.    0.6572  280
649.0   0.700   1649.      88000.    0.5000  214
760.0   0.520   4384.      7187.     0.3500  123
871.0   0.300   49012.     7562.     0.0010  25
982.0   0.150   5000000.   4000.     0.0001  18
1010.0  0.150   5000000.   4000.     0.0001  18
1 2
S    D0
1.0  1.0E4
-----------------------------------------------------
8 5
TI-24-11 B-P WITH BACKSTRESS, TEMP INDEPENDENT
1
T(C) E(GPa) NU     CTE(1E-6/C)
20    93.06  0.3    11.310
20
2
```

```
1 5
n       Zo(MPa)    f1(MPa)   f3   BSMAX(MPa)
1.300   484.       144375.   0.7926   476
1 2
S     D0
1.0   1.0E4
```

```
9 2
B21S/UDRI/Strain control-EDOT=833.3E-6, EL-PL
7
T(C)  E(GPa)  NU      CTE(1E-6/C)
23     114    0.34     8.8700
260    114    0.34     9.8800
482    90     0.34     10.713
650    78     0.34     11.282
760    70     0.34     11.624
815    64     0.34     11.787
900    54.7   0.34     12.027
650
1
7 2
T(C)   SY(MPa)   EP(GPa)
23     1107      0.459
260    1010      1.486
482    810.      2.000
650    350.      0.000
760    120.      0.000
815    110.      0.000
900    94.0      0.000
```

```
10 2
B21S/Round Robin/Stress control, EL-PL
7
T(C)  E(GPa)  NU      CTE(1E-6/C)
21     117    0.34     9.4514
316    101    0.34     9.9880
```

```
 482   95.4  0.34    10.313
 566   78.1  0.34    10.477
 621   73.2  0.34    10.590
 650   70.6  0.34    10.651
 900   50.9  0.34    11.168
 650
 1
 7 2
 T(C)  SY(MPa)  EP(GPa)
 21    1050     3.840
 316   775.     5.400
 482   690.     6.380
 566   470.     16.96
 621   289.     14.72
 650   269.     0.000
 900   94.0     0.000
-----------------------------------------------------
 11 2
 0 degree el-pl ply properties
 5
 T(C) E(GPa) NU     CTE(1E-6/C)
 20    201   0.25    6.54
 315   205   0.25    7.02
 650   176   0.25    6.73
 815   166   0.25    6.61
 1010  155   0.25    6.19
 1010
 1
 5 2
 T(C)  SY(MPa)  EP(GPa)
 20     1256     171.2
 315    249      146.3
 650    582      148.8
 815    565      146.3
 1010   400      140.0
-----------------------------------------------------
```

```
12 2
90 degree ply properties (SCS-6/Ti-24-11/35%)
6
T(C) E(GPa) NU     CTE(1E-6/C)
20    115   0.25    9.42
315   109   0.25    9.98
650   28.8  0.25    10.7
760   21.3  0.25    11.1
815   17.2  0.25    11.37
1010  10    0.25    12.60
1010
1
6 2
T(C)  SY(MPa)  EP(GPa)
20    219      41.4
315   197      6.2
650   144      3.3
760    96      2.86
815    82      2.8
1010   40      2.7
-------------------------------------------------------
13 1
SCS-6 Fiber properties (Steve Johnson, NASA LaRC),cte/udri/ge
10
T(C)   E(GPa) NU   CTE(1E-6/C)
21.11   393  0.25   4.70
93.33   390  0.25   4.81
204.44  386  0.25   4.97
315.56  382  0.25   5.12
426.67  378  0.25   5.26
537.78  374  0.25   5.38
648.89  370  0.25   5.50
760.00  365  0.25   5.60
871.11  361  0.25   5.70
1093.3  354  0.25   5.80
1010
```

```
-----------------------------------------------------
 14 1
 SCS-6 Fiber - R.W. Neu - same as Kroupa CTE??
 10
 T(C)   E(GPa)   NU    CTE(1E-6/C)
 21.11   393    0.25   3.9907
 93.33   390    0.25   4.0289
 204.44  386    0.25   4.0989
 315.56  382    0.25   4.1801
 426.67  378    0.25   4.2655
 537.78  374    0.25   4.3510
 648.89  370    0.25   4.4324
 760.00  365    0.25   4.5074
 871.11  361    0.25   4.5718
 1093.3  354    0.25   4.5723
 900
-----------------------------------------------------
 15 2
 SCS-6/TIMETAL21S NO BONDING 90 BILINEAR BEHAVIOR
 7
 T(C)   E(GPa)    NU    CTE(1E-6/C)
 23     138.4     0.3   8.13
 260    137.99    0.3   8.81
 480    114.25    0.3   9.45
 650    95.04     0.3   9.94
 760    93.03     0.3   10.26
 815    97.25     0.3   10.41
 900    28.65     0.3   10.66
 900
 1
 7 2
 T(C)  SY(MPa)  EP(GPa)
 23     257.4   39.11
 260    226.3   37.65
 480    121.1   38.95
 650    71.28   28.01
```

```
 760    33.49   20.82
 815    21.59   25.64
 900    47.75   0.997
-----------------------------------------------------
 16 6
 TIMETAL 21S B-P WITH DIRECTIONAL HARDENING 4/93
 16
 T(C)  E(GPa)   NU    CTE(1E-6/C)
 23    112.0   0.34   9.7787
 260   108.0   0.34   10.713
 315   106.1   0.34   10.915
 365   104.1   0.34   11.093
 415   101.7   0.34   11.267
 465   99.09   0.34   11.436
 482   98.11   0.34   11.492
 500   97.05   0.34   11.550
 525   95.50   0.34   11.631
 550   93.87   0.34   11.710
 575   92.17   0.34   11.788
 600   90.40   0.34   11.865
 650   86.61   0.34   12.014
 760   77.22   0.34   12.323
 815   71.96   0.34   12.467
 900   63.12   0.34   12.689
 900
 2
 16  4
 T(C)   N    Z0=Z2(1/S) Z3(MPa)  M2(1/MPa)
 23    4.800   1550.0   100.0    0.350
 260   3.500   1300.0   300.0    0.350
 315   3.054   1250.4   390.0    1.502
 365   2.649   1205.4   500.0    2.549
 415   2.243   1160.4   660.0    3.597
 465   1.838   1115.3   960.0    4.644
 482   1.700   1100.0   1100.    5.000
 500   1.500   1089.3   1300.    5.763
```

```
 525   1.280   1074.4   1670.    6.822
 550   1.100   1059.5   2100.    7.881
 575   0.970   1044.6   2600.    8.941
 600   0.820   1029.8   3700.    10.00
 650   0.740   1000.0   3800.    10.00
 760   0.580    600.0   4000.    15.00
 815   0.550    300.0   4100.    30.00
 900   0.550    300.0   4300.    30.00
 1 5
 A1=A2   M1    Z1   R1=R2   DO
 -9999   0.0   1600.  3.0   10000.
-------------------------------------------------------
 17 6
 TIMETAL 21S B-P WITH DIRECTIONAL HARDENING 4/93
 1    ---- SAME AS MAT17, SIMPLIFIED ----
 T(C)  E(GPa)   NU    CTE(1E-6/C)
 23    -9999    0.34    -9999
 23   WARNING:PROGRAM WON'T CALCULATE CTE WRT TO TPROC
 2
 16  4
 T(C)   N     Z0(1/S)  Z3(MPa)  M2(1/MPa)
 23    4.800   1550.0   100.0    0.350
 260   3.500   1300.0   300.0    0.350
 315   3.054   1250.4   390.0    1.502
 365   2.649   1205.4   500.0    2.549
 415   2.243   1160.4   660.0    3.597
 465   1.838   1115.3   960.0    4.644
 482   1.700   1100.0   1100.    5.000
 500   1.500   1089.3   1300.    5.763
 525   1.280   1074.4   1670.    6.822
 550   1.100   1059.5   2100.    7.881
 575   0.970   1044.6   2600.    8.941
 600   0.820   1029.8   3700.    10.00
 650   0.740   1000.0   3800.    10.00
 760   0.580    600.0   4000.    15.00
 815   0.550    300.0   4100.    30.00
```

```
 900   0.550    300.0   4300.    30.00
 1 5
 A1=A2   M1    Z1   R1=R2   DO
 -9999   0.0   1600.  3.0   10000.
-------------------------------------------------------
 18 2
Strain control-EDOT=8.33E-6, EL-PL
 7
 T(C) E(GPa) NU     CTE(1E-6/C)
 23    114   0.34    8.8700
 260   106   0.34    9.8800
 482   96    0.34    10.713
 650   55    0.34    11.282
 760   38    0.34    11.624
 815   24    0.34    11.787
 900   5     0.34    12.027
 650
 1
 7 2
 T(C)  SY(MPa)  EP(GPa)
 23    1065     0.459
 260   865      1.486
 482   685      2.000
 650   125      0.000
 760   31       0.000
 815   20       0.000
 900   10       0.000
-------------------------------------------------------
```

APPENDIX B

Material Properties Database File: TIMETAL.DAT

Summary of Material Properties and Types in material data file TIMETAL.DAT

Material no.	Material Model	Material Definition
1	1	SCS-6 Fiber
2	2	TIMETAL21S/UDRI/ EDOT=833.3E-6, EL-PL
3	2	TIMETAL21S EDOT=8.33E-6, EL-PL
4	6	TIMETAL 21S B-P WITH DIRECTIONAL HARDENING 4/93
5	2	[90] 35% bp timetal weak f/m int edot=833 (Kroupa)
6	2	[90] 35% bp timetal edot=8.33, bilinear fit, (Kroupa)
7	2	[90] 35% bp timetal weak f/m int edot=833,new curve fit
8	2	[90] 35% bp timetal edot=8.33, bilinear, new curve fit
9	2	[90] 35% bp timetal weak f/m int edot=833, MAT5+MAT7
10	4	90 with damage and b-p 4/93
11	6	90 without damage and with b-p 4/93
12	6	TIMETAL 21S B-P w/diff props at 650 to make zd work
13	6	TIMETAL 21S B-P w/diff props at 650 and 815 to make zd work
14	4	90 with damage and b-p 4/93 and diff prop@650
15	4	90 with damage and b-p 4/93 and diff prop@650 & 815
16	4	90 with damage and b-p=MAT10 with matrix cte from mat4

```
Materials for SCS-6/Timetal composite  - TIMETAL.DAT
=====================================================
1 1
SCS-6 Fiber
10
T(C)   E(GPa)   NU    CTE(1E-6/C)
21.11   393    0.25   3.9907
93.33   390    0.25   4.0289
204.44  386    0.25   4.0989
315.56  382    0.25   4.1801
426.67  378    0.25   4.2655
537.78  374    0.25   4.3510
648.89  370    0.25   4.4324
760.00  365    0.25   4.5074
871.11  361    0.25   4.5718
1093.3  354    0.25   4.5723
900
-----------------------------------------------------
2 2
TIMETAL21S/UDRI/ EDOT=833.3E-6, EL-PL
7
T(C) E(GPa) NU     CTE(1E-6/C)
23    114   0.34    8.8700
260   114   0.34    9.8800
482   90    0.34    10.713
650   78    0.34    11.282
760   70    0.34    11.624
815   64    0.34    11.787
900   54.7  0.34    12.027
650
1
7 2
T(C)  SY(MPa)  EP(GPa)
23    1107     0.459
260   1010     1.486
```

```
 482   810.     2.000
 650   350.     0.000
 760   120.     0.000
 815   110.     0.000
 900   94.0     0.000
-----------------------------------------------------
 3 2
 TIMETAL21S EDOT=8.33E-6, EL-PL
 7
 T(C) E(GPa) NU     CTE(1E-6/C)
 23    114   0.34    8.8700
 260   106   0.34    9.8800
 482   96    0.34    10.713
 650   55    0.34    11.282
 760   38    0.34    11.624
 815   24    0.34    11.787
 900   5     0.34    12.027
 650
 1
 7 2
 T(C)  SY(MPa)  EP(GPa)
 23    1065     0.459
 260   865      1.486
 482   685      2.000
 650   125      0.000
 760   31       0.000
 815   20       0.000
 900   10       0.000
-----------------------------------------------------
 4 6
 TIMETAL 21S B-P WITH DIRECTIONAL HARDENING 4/93
 16
 T(C)  E(GPa)   NU    CTE(1E-6/C)
 23    112.0   0.34   9.7787
 260   108.0   0.34   10.713
 315   106.1   0.34   10.915
```

```
365   104.1   0.34   11.093
415   101.7   0.34   11.267
465   99.09   0.34   11.436
482   98.11   0.34   11.492
500   97.05   0.34   11.550
525   95.50   0.34   11.631
550   93.87   0.34   11.710
575   92.17   0.34   11.788
600   90.40   0.34   11.865
650   86.61   0.34   12.014
760   77.22   0.34   12.323
815   71.96   0.34   12.467
900   63.12   0.34   12.689
900
2
16  4
T(C)   N    Z0=Z2(1/S) Z3(MPa)  M2(1/MPa)
23    4.800   1550.0   100.0    0.350
260   3.500   1300.0   300.0    0.350
315   3.054   1250.4   390.0    1.502
365   2.649   1205.4   500.0    2.549
415   2.243   1160.4   660.0    3.597
465   1.838   1115.3   960.0    4.644
482   1.700   1100.0   1100.    5.000
500   1.500   1089.3   1300.    5.763
525   1.280   1074.4   1670.    6.822
550   1.100   1059.5   2100.    7.881
575   0.970   1044.6   2600.    8.941
600   0.820   1029.8   3700.    10.00
650   0.740   1000.0   3800.    10.00
760   0.580    600.0   4000.    15.00
815   0.550    300.0   4100.    30.00
900   0.550    300.0   4300.    30.00
1 5
A1=A2   M1    Z1   R1=R2   DO
-9999   0.0   1600.  3.0   10000.
```

```
-----------------------------------------------------
 5 2
 [90] 35% bp timetal weak f/m int edot=833, Ref:kroupa
 8
 T(C) E(GPa) NU     CTE(1E-6/C)
 23    133   0.19    5.75
 260   128   0.19    6.20
 482   119   0.19    6.91
 538   115   0.18    7.08
 593   112   0.18    7.25
 650   105   0.17    7.42
 815   50    0.17    7.94
 900   20    0.17    8.32
 25
 1
 8 2
 T(C)  SY(MPa)  EP(GPa)
 23    190      62
 260   130      56
 482    70      50
 538    50      50
 593    36      50
 650    17      47
 815    10      28
 900    10      10
-----------------------------------------------------
 6 2
 [90] 35% bp timetal edot=8.33, bilinear fit, Ref:kroupa
 8
 T(C) E(GPa) NU     CTE(1E-6/C)
 23    133   0.19    5.75
 260   128   0.19    6.20
 482   119   0.19    6.91
 538   115   0.18    7.08
 593   112   0.18    7.25
 650   105   0.17    7.42
```

```
815   50    0.17    7.94
900   20    0.17    8.32
25
1
8 2
T(C)  SY(MPa)  EP(GPa)
23    190      62
260   130      56
482    70      50
538    50      50
593    36      50
650    17      45
815    10      20
900    10      10
-----------------------------------------------------
7 2
[90] 35% bp timetal weak f/m int edot=833,new curvefit
8
T(C) E(GPa)  NU     CTE(1E-6/C)
23    85.2   0.19    5.75
260   66.5   0.19    6.20
482   64.4   0.19    6.91
538   60.9   0.18    7.08
593   44.2   0.18    7.25
650   40.4   0.17    7.42
815   31.9   0.17    7.94
900   20.0   0.17    8.32
25
1
8 2
T(C)  SY(MPa)  EP(GPa)
23    554      4.15
260   452      5.00
482   406      1.61
538   347      1.40
593   287      1.26
```

650 194 1.64

815 51.0 0.136

900 10 0

---

8 2

[90] 35% bp timetal edot=8.33, bilinear,new curve fit

8

T(C) E(GPa) NU CTE(1E-6/C)

23 133 0.19 5.75

260 128 0.19 6.20

482 119 0.19 6.91

538 115 0.18 7.08

593 112 0.18 7.25

650 105 0.17 7.42

815 50 0.17 7.94

900 20 0.17 8.32

25

1

8 2

T(C) SY(MPa) EP(GPa)

23 527 4.58

260 435 3.87

482 340 2.51

538 218 2.63

593 131 0.83

650 72.9 0.65

815 10.5 0.08

900 10 0

---

9 2

[90] 35% bp timetal weak f/m int edot=833, MAT5+MAT7

8

T(C) E(GPa) NU CTE(1E-6/C)

23 133 0.19 5.75

260 128 0.19 6.20

482 119 0.19 6.91

```
538   115   0.18    7.08
593   112   0.18    7.25
650   40.4   0.17    7.42
815   31.9   0.17    7.94
900   20.0   0.17    8.32
25
1
8 2
T(C)  SY(MPa)  EP(GPa)
23    190      62
260   130      56
482    70      50
538    50      50
593    36      50
650   194      1.64
815   51.0     0.136
900   10       0
-------------------------------------------------------
10 4
90 with damage and b-p 4/93
8
T(C) E(GPa) NU     CTE(1E-6/C)
23    133   0.19    5.75
260   128   0.19    6.20
482   119   0.19    6.91
538   115   0.18    7.08
593   112   0.18    7.25
650   105   0.17    7.42
815   50    0.17    7.94
900   20    0.17    8.32
25
4
16  4
T(C)   N    Z0=Z2(1/S) Z3(MPa)  M2(1/MPa)
23    4.800   1550.0   100.0    0.350
260   3.500   1300.0   300.0    0.350
```

```
315   3.054   1250.4   390.0    1.502
365   2.649   1205.4   500.0    2.549
415   2.243   1160.4   660.0    3.597
465   1.838   1115.3   960.0    4.644
482   1.700   1100.0   1100.    5.000
500   1.500   1089.3   1300.    5.763
525   1.280   1074.4   1670.    6.822
550   1.100   1059.5   2100.    7.881
575   0.970   1044.6   2600.    8.941
600   0.820   1029.8   3700.    10.00
650   0.740   1000.0   3800.    10.00
760   0.580    600.0   4000.    15.00
815   0.550    300.0   4100.    30.00
900   0.550    300.0   4300.    30.00
1 5
A1=A2   M1    Z1   R1=R2   DO
-9999   0.0   1600.  3.0   10000.
7 1
T     sm
23    190
260   130
482   70
538   50
593   36
650   17
815   0
1 7
scho  scl    m    theta    Dstar  beta  Dch
 80    0     1     100     0.61   0.05  0.5
-------------------------------------------------------
11 6
90 without damage and with b-p 4/93
8
T(C) E(GPa) NU     CTE(1E-6/C)
23    133   0.19    5.75
260   128   0.19    6.20
```

```
482   119   0.19    6.91
538   115   0.18    7.08
593   112   0.18    7.25
650   105   0.17    7.42
815   50    0.17    7.94
900   20    0.17    8.32
25
2
16  4
T(C)   N    Z0=Z2(1/S) Z3(MPa)  M2(1/MPa)
23    4.800   1550.0   100.0    0.350
260   3.500   1300.0   300.0    0.350
315   3.054   1250.4   390.0    1.502
365   2.649   1205.4   500.0    2.549
415   2.243   1160.4   660.0    3.597
465   1.838   1115.3   960.0    4.644
482   1.700   1100.0   1100.    5.000
500   1.500   1089.3   1300.    5.763
525   1.280   1074.4   1670.    6.822
550   1.100   1059.5   2100.    7.881
575   0.970   1044.6   2600.    8.941
600   0.820   1029.8   3700.    10.00
650   0.740   1000.0   3800.    10.00
760   0.580    600.0   4000.    15.00
815   0.550    300.0   4100.    30.00
900   0.550    300.0   4300.    30.00
1 5
A1=A2   M1    Z1   R1=R2   DO
-9999   0.0   1600.  3.0   10000.
-------------------------------------------------------
12 6
TIMETAL 21S B-P WITH Diff props at 650 to make zd work
16
T(C)  E(GPa)   NU    CTE(1E-6/C)
23    112.0   0.34   9.7787
260   108.0   0.34   10.713
```

```
315   106.1   0.34   10.915
365   104.1   0.34   11.093
415   101.7   0.34   11.267
465   99.09   0.34   11.436
482   98.11   0.34   11.492
500   97.05   0.34   11.550
525   95.50   0.34   11.631
550   93.87   0.34   11.710
575   92.17   0.34   11.788
600   90.40   0.34   11.865
650   86.61   0.34   12.014
760   77.22   0.34   12.323
815   71.96   0.34   12.467
900   63.12   0.34   12.689
900
2
16  4
T(C)    N     Z0=Z2(1/S) Z3(MPa)  M2(1/MPa)
23    4.800   1550.0   100.0    0.350
260   3.500   1300.0   300.0    0.350
315   3.054   1250.4   390.0    1.502
365   2.649   1205.4   500.0    2.549
415   2.243   1160.4   660.0    3.597
465   1.838   1115.3   960.0    4.644
482   1.700   1100.0   1100.    5.000
500   1.500   1089.3   1300.    5.763
525   1.280   1074.4   1670.    6.822
550   1.100   1059.5   2100.    7.881
575   0.970   1044.6   2600.    8.941
600   0.820   1029.8   3700.    10.00
650   0.900   1500.0   1000.    10.00
760   0.580    600.0   4000.    15.00
815   0.550    300.0   4100.    30.00
900   0.550    300.0   4300.    30.00
1 5
A1=A2   M1    Z1   R1=R2   DO
```

```
 -9999   0.0   1600.  3.0   10000.
-------------------------------------------------------
 13 6
 TIMETAL 21S B-P w/diff props at 650 & 815 to make zd work
 16
 T(C)  E(GPa)   NU    CTE(1E-6/C)
 23    112.0   0.34   9.7787
 260   108.0   0.34   10.713
 315   106.1   0.34   10.915
 365   104.1   0.34   11.093
 415   101.7   0.34   11.267
 465   99.09   0.34   11.436
 482   98.11   0.34   11.492
 500   97.05   0.34   11.550
 525   95.50   0.34   11.631
 550   93.87   0.34   11.710
 575   92.17   0.34   11.788
 600   90.40   0.34   11.865
 650   86.61   0.34   12.014
 760   77.22   0.34   12.323
 815   71.96   0.34   12.467
 900   63.12   0.34   12.689
 900
 2
 15  4
 T(C)   N    Z0=Z2(1/S) Z3(MPa)  M2(1/MPa)
 23    4.800   1550.0   100.0    0.350
 260   3.500   1300.0   300.0    0.350
 315   3.054   1250.4   390.0    1.502
 365   2.649   1205.4   500.0    2.549
 415   2.243   1160.4   660.0    3.597
 465   1.838   1115.3   960.0    4.644
 482   1.700   1100.0   1100.    5.000
 500   1.500   1089.3   1300.    5.763
 525   1.280   1074.4   1670.    6.822
 550   1.100   1059.5   2100.    7.881
```

```
575   0.970   1044.6   2600.    8.941
600   0.820   1029.8   3700.    10.00
650   0.900   1500.0   1000.    10.00
815   0.570   1000.0    950.    30.00
900   0.550    300.0   4300.    30.00
1 5
A1=A2   M1    Z1   R1=R2   DO
-9999   0.0   1600.  3.0   10000.
```

```
14 4
90 with damage and b-p 4/93 and diff prop@650
8
T(C) E(GPa) NU     CTE(1E-6/C)
23    133   0.19    5.75
260   128   0.19    6.20
482   119   0.19    6.91
538   115   0.18    7.08
593   112   0.18    7.25
650   105   0.17    7.42
815   50    0.17    7.94
900   20    0.17    8.32
25
4
16  4
T(C)   N    Z0=Z2(1/S) Z3(MPa)  M2(1/MPa)
23    4.800   1550.0   100.0    0.350
260   3.500   1300.0   300.0    0.350
315   3.054   1250.4   390.0    1.502
365   2.649   1205.4   500.0    2.549
415   2.243   1160.4   660.0    3.597
465   1.838   1115.3   960.0    4.644
482   1.700   1100.0   1100.    5.000
500   1.500   1089.3   1300.    5.763
525   1.280   1074.4   1670.    6.822
550   1.100   1059.5   2100.    7.881
575   0.970   1044.6   2600.    8.941
```

```
600   0.820   1029.8   3700.    10.00
650   0.900   1500.0   1000.    10.00
760   0.580    600.0   4000.    15.00
815   0.550    300.0   4100.    30.00
900   0.550    300.0   4300.    30.00
1 5
A1=A2   M1    Z1   R1=R2   DO
-9999   0.0   1600.  3.0   10000.
7 1
T     sm
23    190
260   130
482   70
538   50
593   36
650   17
815   0
1 7
scho  scl    m    theta    Dstar  beta  Dch
 80    0     1     100     0.61   0.05  0.5
-------------------------------------------------------
15 4
90 with damage and b-p 4/93 and diff prop@650 & 815
8
T(C) E(GPa) NU     CTE(1E-6/C)
23    133   0.19    5.75
260   128   0.19    6.20
482   119   0.19    6.91
538   115   0.18    7.08
593   112   0.18    7.25
650   105   0.17    7.42
815   50    0.17    7.94
900   20    0.17    8.32
25
4
15  4
```

```
 T(C)   N    Z0=Z2(1/S) Z3(MPa)  M2(1/MPa)
 23    4.800   1550.0   100.0    0.350
 260   3.500   1300.0   300.0    0.350
 315   3.054   1250.4   390.0    1.502
 365   2.649   1205.4   500.0    2.549
 415   2.243   1160.4   660.0    3.597
 465   1.838   1115.3   960.0    4.644
 482   1.700   1100.0   1100.    5.000
 500   1.500   1089.3   1300.    5.763
 525   1.280   1074.4   1670.    6.822
 550   1.100   1059.5   2100.    7.881
 575   0.970   1044.6   2600.    8.941
 600   0.820   1029.8   3700.    10.00
 650   0.900   1500.0   1000.    10.00
 815   0.570   1000.0    950.    30.00
 900   0.550    300.0   4300.    30.00
 1 5
 A1=A2   M1    Z1   R1=R2   DO
 -9999   0.0   1600.  3.0   10000.
 7 1
 T     sm
 23    190
 260   130
 482   70
 538   50
 593   36
 650   17
 815   0
 1 7
 scho  scl    m    theta    Dstar  beta  Dch
  80    0     1     100     0.61   0.05  0.5
-------------------------------------------------------
 16 4
 90 with damage and b-p=MAT10 with matrix cte from mat4
 8
 T(C) E(GPa) NU     CTE(1E-6/C)
```

```
23    133   0.19    9.7787
260   128   0.19    10.713
482   119   0.19    11.492
538   115   0.18    11.670
593   112   0.18    11.860
650   105   0.17    12.014
815   50    0.17    12.467
900   20    0.17    12.689
900
4
16  4
T(C)   N    Z0=Z2(1/S) Z3(MPa)  M2(1/MPa)
23    4.800   1550.0   100.0    0.350
260   3.500   1300.0   300.0    0.350
315   3.054   1250.4   390.0    1.502
365   2.649   1205.4   500.0    2.549
415   2.243   1160.4   660.0    3.597
465   1.838   1115.3   960.0    4.644
482   1.700   1100.0   1100.    5.000
500   1.500   1089.3   1300.    5.763
525   1.280   1074.4   1670.    6.822
550   1.100   1059.5   2100.    7.881
575   0.970   1044.6   2600.    8.941
600   0.820   1029.8   3700.    10.00
650   0.740   1000.0   3800.    10.00
760   0.580    600.0   4000.    15.00
815   0.550    300.0   4100.    30.00
900   0.550    300.0   4300.    30.00
1 5
A1=A2   M1    Z1   R1=R2   DO
-9999   0.0   1600.  3.0   10000.
7 1
T     sm
23    190
260   130
482   70
```

```
 538   50
 593   36
 650   17
 815   0
 1 7
 scho  scl    m    theta    Dstar  beta  Dch
  80    0     1     100     0.61   0.05  0.5
-----------------------------------------------------
```

APPENDIX C

Output Files for Demonstration Runs

```
          ************************************
          *                                  *
          *   F I D E P 2 - VERSION 6        *
          *                                  *
          ************************************

  ************ PROBLEM TITLE ************

Bodner Partom with Back Stress at 23C (strain rate = 833E-6/s)

  ************ GEOMETRY TYPE ************

     1-D Laminate Model


  ************ LOADING TYPE ************

      Strain Control


  ********* LOADING HISTORY ************

  POINTS IN HISTORY  2

      Step          Time      Temperature  Axial Strain
     .0000E+00    .0000E+00   2.3000E+01    .0000E+00
    4.8000E+02   4.8000E+01   2.3000E+01   4.0000E-02


  ********* GEOMETRY INFORMATION  ***********

  Number of Cells  1

       For Cell Number : 1

            Material Number :  3
            Volume Fraction :  1.0
            Nodes in cell   :  2


  ********** OUTPUT INFORMATION  ************

  Output at Interface for Material:  1


  ********** MATERIAL INFORMATION  ************


  Material for Cell Number :  1

   Sherwood's Model with Back Stress for TimetalÒ21S

  Constitutive model: Bodner-Partom with Back Stress


  ---------- MATERIAL PROPERTIES  ----------


    Temp         E (GPa)         NU        CTE (1E-6/C)
   2.3000E+01   1.1430E+02   3.4000E-01   5.8314E+00
   2.6000E+02   1.0800E+02   3.4000E-01   6.8976E+00
   4.8200E+02   9.0370E+01   3.4000E-01   7.8963E+00
   5.6000E+02   8.3020E+01   3.4000E-01   8.2174E+00
   5.8400E+02   8.0760E+01   3.4000E-01   8.3184E+00
   6.0000E+02   7.9250E+01   3.4000E-01   8.3825E+00
   6.1000E+02   7.8310E+01   3.4000E-01   8.4179E+00
   6.2000E+02   7.7370E+01   3.4000E-01   8.4582E+00
   6.2700E+02   7.6710E+01   3.4000E-01   8.4866E+00
   6.3400E+02   7.6050E+01   3.4000E-01   8.5148E+00
   6.3900E+02   7.5580E+01   3.4000E-01   8.5324E+00
   6.4300E+02   7.5200E+01   3.4000E-01   8.5490E+00
   6.4700E+02   7.4820E+01   3.4000E-01   8.5615E+00
   6.5000E+02   7.4540E+01   3.4000E-01   8.5769E+00
   7.6000E+02   6.0280E+01   3.4000E-01   8.9923E+00
   8.1510E+02   5.3220E+01   3.4000E-01   9.1920E+00
   9.0000E+02   5.3220E+01   3.4000E-01   9.4900E+00

  Reference Temperature =  23.0
  ----------------------------------------

    Temp          n          Zo           F1          F3          BSMAX
```

```
 2.2990E+01   1.9500E+00   3.3900E+02   4.4990E+04   7.0000E-01   7.4400E+02
 2.6000E+02   1.8500E+00   3.8200E+02   3.7000E+04   6.5000E-01   5.7300E+02
 4.8200E+02   1.5000E+00   4.9800E+02   3.5590E+04   6.0000E-01   5.1200E+02
 5.6000E+02   8.5000E+00   1.5650E+03   2.8580E+04   4.7460E-01   3.0000E+02
 5.8400E+02   6.5000E+00   3.1730E+03   2.6430E+04   3.7590E-01   2.3500E+02
 6.0000E+02   5.1700E+00   6.6840E+03   2.4990E+04   3.1010E-01   1.9100E+02
 6.1000E+02   4.3300E+00   1.3260E+04   2.4090E+04   2.6900E-01   1.6400E+02
 6.2000E+02   3.5000E+00   3.5970E+04   2.3190E+04   2.2790E-01   1.3600E+02
 6.2700E+02   2.9200E+00   1.0070E+05   2.2570E+04   1.9910E-01   1.1800E+02
 6.3400E+02   2.3300E+00   4.6810E+05   2.1940E+04   1.7030E-01   9.9000E+01
 6.3900E+02   1.9200E+00   2.4720E+06   2.1490E+04   1.4970E-01   8.5000E+01
 6.4300E+02   1.5800E+00   1.7520E+07   2.1130E+04   1.3330E-01   7.4000E+01
 6.4700E+02   1.2500E+00   3.5190E+08   2.0770E+04   1.1680E-01   6.3000E+01
 6.5000E+02   1.0000E+00   1.2400E+10   2.0500E+04   1.0450E-01   5.5000E+01
 7.6000E+02   1.2000E+00   2.4700E+08   9.9000E+02   2.4000E-03   3.0000E+00
 8.1510E+02   1.1600E+00   2.4500E+08   7.6000E+02   1.9000E-03   1.0000E+00
 9.0000E+02   7.0000E-01   2.4300E+08   5.0000E+02   5.0000E-04   5.0000E-01
 ----------------------------------------

  D0
10000.0
 ----------------------------------------


 -------------------- OUTPUT -------------------
```

STEP	TIME	TEMPERATURE	SZ-APP	SZ-LAM1	SZ-LAM2	SZ-LAM3	ETOT
1	1.0000E-01	2.3000E+01	9.5250E+00	9.5250E+00	.0000E+00	.0000E+00	8.3333E-05
20	2.0000E+00	2.3000E+01	1.9050E+02	1.9050E+02	.0000E+00	.0000E+00	1.6667E-03
40	4.0000E+00	2.3000E+01	3.8100E+02	3.8100E+02	.0000E+00	.0000E+00	3.3333E-03
60	6.0000E+00	2.3000E+01	5.1082E+02	5.1082E+02	.0000E+00	.0000E+00	5.0000E-03
80	8.0000E+00	2.3000E+01	6.1515E+02	6.1515E+02	.0000E+00	.0000E+00	6.6667E-03
100	1.0000E+01	2.3000E+01	7.1194E+02	7.1194E+02	.0000E+00	.0000E+00	8.3333E-03
120	1.2000E+01	2.3000E+01	8.0051E+02	8.0051E+02	.0000E+00	.0000E+00	1.0000E-02
140	1.4000E+01	2.3000E+01	8.8025E+02	8.8025E+02	.0000E+00	.0000E+00	1.1667E-02
160	1.6000E+01	2.3000E+01	9.5071E+02	9.5071E+02	.0000E+00	.0000E+00	1.3333E-02
180	1.8000E+01	2.3000E+01	1.0117E+03	1.0117E+03	.0000E+00	.0000E+00	1.5000E-02
200	2.0000E+01	2.3000E+01	1.0632E+03	1.0632E+03	.0000E+00	.0000E+00	1.6667E-02
220	2.2000E+01	2.3000E+01	1.1057E+03	1.1057E+03	.0000E+00	.0000E+00	1.8333E-02
240	2.4000E+01	2.3000E+01	1.1399E+03	1.1399E+03	.0000E+00	.0000E+00	2.0000E-02
260	2.6000E+01	2.3000E+01	1.1669E+03	1.1669E+03	.0000E+00	.0000E+00	2.1667E-02
280	2.8000E+01	2.3000E+01	1.1876E+03	1.1876E+03	.0000E+00	.0000E+00	2.3333E-02
300	3.0000E+01	2.3000E+01	1.2034E+03	1.2034E+03	.0000E+00	.0000E+00	2.5000E-02
320	3.2000E+01	2.3000E+01	1.2151E+03	1.2151E+03	.0000E+00	.0000E+00	2.6667E-02
340	3.4000E+01	2.3000E+01	1.2237E+03	1.2237E+03	.0000E+00	.0000E+00	2.8333E-02
360	3.6000E+01	2.3000E+01	1.2300E+03	1.2300E+03	.0000E+00	.0000E+00	3.0000E-02
380	3.8000E+01	2.3000E+01	1.2346E+03	1.2346E+03	.0000E+00	.0000E+00	3.1667E-02
400	4.0000E+01	2.3000E+01	1.2379E+03	1.2379E+03	.0000E+00	.0000E+00	3.3333E-02
420	4.2000E+01	2.3000E+01	1.2402E+03	1.2402E+03	.0000E+00	.0000E+00	3.5000E-02
440	4.4000E+01	2.3000E+01	1.2419E+03	1.2419E+03	.0000E+00	.0000E+00	3.6667E-02
460	4.6000E+01	2.3000E+01	1.2431E+03	1.2431E+03	.0000E+00	.0000E+00	3.8333E-02
480	4.8000E+01	2.3000E+01	1.2440E+03	1.2440E+03	.0000E+00	.0000E+00	4.0000E-02

```
   ************************************
   *                                  *
   *   F I D E P 2 - VERSION 6        *
   *                                  *
   ************************************

  ************ PROBLEM TITLE ************

Bodner Partom with Back Stress at 450C (strain rate = 833E-6/s)

  ************ GEOMETRY TYPE ************

     1-D Laminate Model

  ************ LOADING TYPE ************

      Strain Control

  ********* LOADING HISTORY ************

  POINTS IN HISTORY  2

      Step          Time      Temperature  Axial Strain
     .0000E+00    .0000E+00   4.5000E+02    .0000E+00
    4.8000E+02   4.8000E+01   4.5000E+02   4.0000E-02

  ********* GEOMETRY INFORMATION  ***********

  Number of Cells  1

       For Cell Number : 1

            Material Number :  3
            Volume Fraction :  1.0
            Nodes in cell   :  2


  ********** OUTPUT INFORMATION  ************

  Output at Interface for Material:  1


  ********** MATERIAL INFORMATION  ************


  Material for Cell Number :  1

   Sherwood's Model with Back Stress for TimetalÒ21S

  Constitutive model: Bodner-Partom with Back Stress


  ---------- MATERIAL PROPERTIES  ----------


    Temp         E (GPa)        NU        CTE (1E-6/C)
   2.3000E+01   1.1430E+02   3.4000E-01   7.7657E+00
   2.6000E+02   1.0800E+02   3.4000E-01   8.8486E+00
   4.8200E+02   9.0370E+01   3.4000E-01   9.6386E+00
   5.6000E+02   8.3020E+01   3.4000E-01   9.9705E+00
   5.8400E+02   8.0760E+01   3.4000E-01   1.0079E+01
   6.0000E+02   7.9250E+01   3.4000E-01   1.0138E+01
   6.1000E+02   7.8310E+01   3.4000E-01   1.0158E+01
   6.2000E+02   7.7370E+01   3.4000E-01   1.0197E+01
   6.2700E+02   7.6710E+01   3.4000E-01   1.0226E+01
   6.3400E+02   7.6050E+01   3.4000E-01   1.0253E+01
   6.3900E+02   7.5580E+01   3.4000E-01   1.0265E+01
   6.4300E+02   7.5200E+01   3.4000E-01   1.0282E+01
   6.4700E+02   7.4820E+01   3.4000E-01   1.0286E+01
   6.5000E+02   7.4540E+01   3.4000E-01   1.0309E+01
   7.6000E+02   6.0280E+01   3.4000E-01   1.0682E+01
   8.1510E+02   5.3220E+01   3.4000E-01   1.0860E+01
   9.0000E+02   5.3220E+01   3.4000E-01   1.1126E+01

  Reference Temperature =  450.0
  ---------------------------------------
```

Temp	n	Zo	F1	F3	BSMAX
2.2990E+01	1.9500E+00	3.3900E+02	4.4990E+04	7.0000E-01	7.4400E+02
2.6000E+02	1.8500E+00	3.8200E+02	3.7000E+04	6.5000E-01	5.7300E+02
4.8200E+02	1.5000E+00	4.9800E+02	3.5590E+04	6.0000E-01	5.1200E+02
5.6000E+02	8.5000E+00	1.5650E+03	2.8580E+04	4.7460E-01	3.0000E+02
5.8400E+02	6.5000E+00	3.1730E+03	2.6430E+04	3.7590E-01	2.3500E+02
6.0000E+02	5.1700E+00	6.6840E+03	2.4990E+04	3.1010E-01	1.9100E+02
6.1000E+02	4.3300E+00	1.3260E+04	2.4090E+04	2.6900E-01	1.6400E+02
6.2000E+02	3.5000E+00	3.5970E+04	2.3190E+04	2.2790E-01	1.3600E+02
6.2700E+02	2.9200E+00	1.0070E+05	2.2570E+04	1.9910E-01	1.1800E+02
6.3400E+02	2.3300E+00	4.6810E+05	2.1940E+04	1.7030E-01	9.9000E+01
6.3900E+02	1.9200E+00	2.4720E+06	2.1490E+04	1.4970E-01	8.5000E+01
6.4300E+02	1.5800E+00	1.7520E+07	2.1130E+04	1.3330E-01	7.4000E+01
6.4700E+02	1.2500E+00	3.5190E+08	2.0770E+04	1.1680E-01	6.3000E+01
6.5000E+02	1.0000E+00	1.2400E+10	2.0500E+04	1.0450E-01	5.5000E+01
7.6000E+02	1.2000E+00	2.4700E+08	9.9000E+02	2.4000E-03	3.0000E+00
8.1510E+02	1.1600E+00	2.4500E+08	7.6000E+02	1.9000E-03	1.0000E+00
9.0000E+02	7.0000E-01	2.4300E+08	5.0000E+02	5.0000E-04	5.0000E-01

D0
10000.0

---------- OUTPUT ----------

STEP	TIME	TEMPERATURE	SZ-APP	SZ-LAM1	SZ-LAM2	SZ-LAM3	ETOT
1	1.0000E-01	4.5000E+02	7.7426E+00	7.7426E+00	.0000E+00	.0000E+00	8.3333E-05
20	2.0000E+00	4.5000E+02	1.5485E+02	1.5485E+02	.0000E+00	.0000E+00	1.6667E-03
40	4.0000E+00	4.5000E+02	3.0970E+02	3.0970E+02	.0000E+00	.0000E+00	3.3333E-03
60	6.0000E+00	4.5000E+02	4.2060E+02	4.2060E+02	.0000E+00	.0000E+00	5.0000E-03
80	8.0000E+00	4.5000E+02	4.9384E+02	4.9384E+02	.0000E+00	.0000E+00	6.6667E-03
100	1.0000E+01	4.5000E+02	5.6095E+02	5.6095E+02	.0000E+00	.0000E+00	8.3333E-03
120	1.2000E+01	4.5000E+02	6.2161E+02	6.2161E+02	.0000E+00	.0000E+00	1.0000E-02
140	1.4000E+01	4.5000E+02	6.7563E+02	6.7563E+02	.0000E+00	.0000E+00	1.1667E-02
160	1.6000E+01	4.5000E+02	7.2294E+02	7.2294E+02	.0000E+00	.0000E+00	1.3333E-02
180	1.8000E+01	4.5000E+02	7.6363E+02	7.6363E+02	.0000E+00	.0000E+00	1.5000E-02
200	2.0000E+01	4.5000E+02	7.9802E+02	7.9802E+02	.0000E+00	.0000E+00	1.6667E-02
220	2.2000E+01	4.5000E+02	8.2654E+02	8.2654E+02	.0000E+00	.0000E+00	1.8333E-02
240	2.4000E+01	4.5000E+02	8.4979E+02	8.4979E+02	.0000E+00	.0000E+00	2.0000E-02
260	2.6000E+01	4.5000E+02	8.6844E+02	8.6844E+02	.0000E+00	.0000E+00	2.1667E-02
280	2.8000E+01	4.5000E+02	8.8318E+02	8.8318E+02	.0000E+00	.0000E+00	2.3333E-02
300	3.0000E+01	4.5000E+02	8.9469E+02	8.9469E+02	.0000E+00	.0000E+00	2.5000E-02
320	3.2000E+01	4.5000E+02	9.0358E+02	9.0358E+02	.0000E+00	.0000E+00	2.6667E-02
340	3.4000E+01	4.5000E+02	9.1039E+02	9.1039E+02	.0000E+00	.0000E+00	2.8333E-02
360	3.6000E+01	4.5000E+02	9.1557E+02	9.1557E+02	.0000E+00	.0000E+00	3.0000E-02
380	3.8000E+01	4.5000E+02	9.1949E+02	9.1949E+02	.0000E+00	.0000E+00	3.1667E-02
400	4.0000E+01	4.5000E+02	9.2244E+02	9.2244E+02	.0000E+00	.0000E+00	3.3333E-02
420	4.2000E+01	4.5000E+02	9.2465E+02	9.2465E+02	.0000E+00	.0000E+00	3.5000E-02
440	4.4000E+01	4.5000E+02	9.2631E+02	9.2631E+02	.0000E+00	.0000E+00	3.6667E-02
460	4.6000E+01	4.5000E+02	9.2755E+02	9.2755E+02	.0000E+00	.0000E+00	3.8333E-02
480	4.8000E+01	4.5000E+02	9.2848E+02	9.2848E+02	.0000E+00	.0000E+00	4.0000E-02

```
    ************************************
    *                                  *
    *   F I D E P 2 - VERSION 6        *
    *                                  *
    ************************************

  ************ PROBLEM TITLE ************

Bodner Partom with Dir. Hardening at 23C (strain rate = 8.33E-6/s)

  ************ GEOMETRY TYPE ************

     1-D Laminate Model

  ************ LOADING TYPE ************

      Strain Control

  ********* LOADING HISTORY ************

  POINTS IN HISTORY  2

      Step          Time      Temperature  Axial Strain
    .0000E+00    .0000E+00   2.3000E+01    .0000E+00
   4.8000E+02   4.8000E+03   2.3000E+01   4.0000E-02

  ********* GEOMETRY INFORMATION  ***********

  Number of Cells  1

       For Cell Number : 1

            Material Number :  4
            Volume Fraction :  1.0
            Nodes in cell   :  2


  ********** OUTPUT INFORMATION  ************

  Output at Interface for Material:  1


  ********** MATERIAL INFORMATION  ************


  Material for Cell Number :  1

Bodner-Partom Theory with Directional Hardening for TimetalÒ21S

 Constitutive model: Bodner-Partom with Directional Hardening


  -------------------- OUTPUT -------------------
```

STEP	TIME	TEMPERATURE	SZ-APP	SZ-LAM1	SZ-LAM2	SZ-LAM3	ETOT
1	1.0000E+01	2.3000E+01	9.3333E+00	9.3333E+00	.0000E+00	.0000E+00	8.3333E-05
20	2.0000E+02	2.3000E+01	1.8667E+02	1.8667E+02	.0000E+00	.0000E+00	1.6667E-03
40	4.0000E+02	2.3000E+01	3.7333E+02	3.7333E+02	.0000E+00	.0000E+00	3.3333E-03
60	6.0000E+02	2.3000E+01	5.6000E+02	5.6000E+02	.0000E+00	.0000E+00	5.0000E-03
80	8.0000E+02	2.3000E+01	7.4667E+02	7.4667E+02	.0000E+00	.0000E+00	6.6667E-03
100	1.0000E+03	2.3000E+01	9.3333E+02	9.3333E+02	.0000E+00	.0000E+00	8.3333E-03
120	1.2000E+03	2.3000E+01	1.0609E+03	1.0609E+03	.0000E+00	.0000E+00	1.0000E-02
140	1.4000E+03	2.3000E+01	1.0851E+03	1.0851E+03	.0000E+00	.0000E+00	1.1667E-02
160	1.6000E+03	2.3000E+01	1.0997E+03	1.0997E+03	.0000E+00	.0000E+00	1.3333E-02
180	1.8000E+03	2.3000E+01	1.1080E+03	1.1080E+03	.0000E+00	.0000E+00	1.5000E-02
200	2.0000E+03	2.3000E+01	1.1126E+03	1.1126E+03	.0000E+00	.0000E+00	1.6667E-02
220	2.2000E+03	2.3000E+01	1.1150E+03	1.1150E+03	.0000E+00	.0000E+00	1.8333E-02
240	2.4000E+03	2.3000E+01	1.1162E+03	1.1162E+03	.0000E+00	.0000E+00	2.0000E-02
260	2.6000E+03	2.3000E+01	1.1169E+03	1.1169E+03	.0000E+00	.0000E+00	2.1667E-02
280	2.8000E+03	2.3000E+01	1.1172E+03	1.1172E+03	.0000E+00	.0000E+00	2.3333E-02
300	3.0000E+03	2.3000E+01	1.1174E+03	1.1174E+03	.0000E+00	.0000E+00	2.5000E-02
320	3.2000E+03	2.3000E+01	1.1175E+03	1.1175E+03	.0000E+00	.0000E+00	2.6667E-02
340	3.4000E+03	2.3000E+01	1.1176E+03	1.1176E+03	.0000E+00	.0000E+00	2.8333E-02
360	3.6000E+03	2.3000E+01	1.1176E+03	1.1176E+03	.0000E+00	.0000E+00	3.0000E-02
380	3.8000E+03	2.3000E+01	1.1176E+03	1.1176E+03	.0000E+00	.0000E+00	3.1667E-02
400	4.0000E+03	2.3000E+01	1.1176E+03	1.1176E+03	.0000E+00	.0000E+00	3.3333E-02

420	4.2000E+03	2.3000E+01	1.1176E+03	1.1176E+03	.0000E+00	.0000E+00	3.5000E-02
440	4.4000E+03	2.3000E+01	1.1176E+03	1.1176E+03	.0000E+00	.0000E+00	3.6667E-02
460	4.6000E+03	2.3000E+01	1.1176E+03	1.1176E+03	.0000E+00	.0000E+00	3.8333E-02
480	4.8000E+03	2.3000E+01	1.1176E+03	1.1176E+03	.0000E+00	.0000E+00	4.0000E-02

```
     ************************************
     *                                  *
     *   F I D E P 2 - VERSION 6        *
     *                                  *
     ************************************

  ************ PROBLEM TITLE ************

Bodner Partom with Dir. Hardening at 650C (strain rate = 8.33E-6/s)

  ************ GEOMETRY TYPE ************

     1-D Laminate Model

  ************ LOADING TYPE ************

      Strain Control

  ********* LOADING HISTORY ************

  POINTS IN HISTORY  2

      Step          Time      Temperature  Axial Strain
    .0000E+00    .0000E+00   6.5000E+02    .0000E+00
   1.6000E+03   4.8000E+03   6.5000E+02   4.0000E-02

  ********* GEOMETRY INFORMATION  ***********

  Number of Cells  1

       For Cell Number : 1

            Material Number :  4
            Volume Fraction :  1.0
            Nodes in cell   :  2

  ********** OUTPUT INFORMATION  ************

  Output at Interface for Material:  1

  ********** MATERIAL INFORMATION  ************

  Material for Cell Number :  1

Bodner-Partom Theory with Directional Hardening for TimetalÒ21S

 Constitutive model: Bodner-Partom with Directional Hardening

---------- MATERIAL PROPERTIES  ----------

   T(C)        E(GPa)       NU       CTE(1E-6/C)
   2.3000E+01   1.1200E+02   3.4000E-01   8.8874E+00
   2.6000E+02   1.0800E+02   3.4000E-01   9.8790E+00
   3.1500E+02   1.0610E+02   3.4000E-01   1.0095E+01
   3.6500E+02   1.0410E+02   3.4000E-01   1.0285E+01
   4.1500E+02   1.0170E+02   3.4000E-01   1.0472E+01
   4.6500E+02   9.9090E+01   3.4000E-01   1.0655E+01
   4.8200E+02   9.8110E+01   3.4000E-01   1.0715E+01
   5.0000E+02   9.7050E+01   3.4000E-01   1.0777E+01
   5.2500E+02   9.5500E+01   3.4000E-01   1.0865E+01
   5.5000E+02   9.3870E+01   3.4000E-01   1.0950E+01
   5.7500E+02   9.2170E+01   3.4000E-01   1.1035E+01
   6.0000E+02   9.0400E+01   3.4000E-01   1.1120E+01
   6.5000E+02   8.6610E+01   3.4000E-01   1.1276E+01
   7.6000E+02   7.7220E+01   3.4000E-01   1.1621E+01
   8.1500E+02   7.1960E+01   3.4000E-01   1.1781E+01
   9.0000E+02   6.3120E+01   3.4000E-01   1.2014E+01
  Reference Temperature =  650.0
  ----------------------------------------

   T(C)        N     Z0=Z2(1/S)     Z3(MPa)    M2(1/MPa)
   2.3000E+01   4.8000E+00   1.5500E+03   1.0000E+02   3.5000E-01
   2.6000E+02   3.5000E+00   1.3000E+03   3.0000E+02   3.5000E-01
   3.1500E+02   3.0540E+00   1.2504E+03   3.9000E+02   1.5020E+00
   3.6500E+02   2.6490E+00   1.2054E+03   5.0000E+02   2.5490E+00
   4.1500E+02   2.2430E+00   1.1604E+03   6.6000E+02   3.5970E+00
   4.6500E+02   1.8380E+00   1.1153E+03   9.6000E+02   4.6440E+00
   4.8200E+02   1.7000E+00   1.1000E+03   1.1000E+03   5.0000E+00
   5.0000E+02   1.5000E+00   1.0893E+03   1.3000E+03   5.7630E+00
   5.2500E+02   1.2800E+00   1.0744E+03   1.6700E+03   6.8220E+00
   5.5000E+02   1.1000E+00   1.0595E+03   2.1000E+03   7.8810E+00
   5.7500E+02   9.7000E-01   1.0446E+03   2.6000E+03   8.9410E+00
   6.0000E+02   8.2000E-01   1.0298E+03   3.7000E+03   1.0000E+01
```

```
   6.5000E+02   7.4000E-01   1.0000E+03   3.8000E+03   1.0000E+01
   7.6000E+02   5.8000E-01   6.0000E+02   4.0000E+03   1.5000E+01
   8.1500E+02   5.5000E-01   3.0000E+02   4.1000E+03   3.0000E+01
   9.0000E+02   5.5000E-01   3.0000E+02   4.3000E+03   3.0000E+01
  ----------------------------------------

    A1=A2      M1          Z1         R1=R2       DO
 -9999.0 .0 1600.0 3.0 10000.0
  ----------------------------------------

  -------------------- OUTPUT -------------------
```

STEP	TIME	TEMPERATURE	SZ-APP	SZ-LAM1	SZ-LAM2	SZ-LAM3	ETOT
1	3.0000E+00	6.5000E+02	2.1653E+00	2.1653E+00	.0000E+00	.0000E+00	2.5000E-05
40	1.2000E+02	6.5000E+02	8.3912E+01	8.3912E+01	.0000E+00	.0000E+00	1.0000E-03
80	2.4000E+02	6.5000E+02	1.3222E+02	1.3222E+02	.0000E+00	.0000E+00	2.0000E-03
120	3.6000E+02	6.5000E+02	1.3895E+02	1.3895E+02	.0000E+00	.0000E+00	3.0000E-03
160	4.8000E+02	6.5000E+02	1.3827E+02	1.3827E+02	.0000E+00	.0000E+00	4.0000E-03
200	6.0000E+02	6.5000E+02	1.3826E+02	1.3826E+02	.0000E+00	.0000E+00	5.0000E-03
240	7.2000E+02	6.5000E+02	1.3826E+02	1.3826E+02	.0000E+00	.0000E+00	6.0000E-03
280	8.4000E+02	6.5000E+02	1.3826E+02	1.3826E+02	.0000E+00	.0000E+00	7.0000E-03
320	9.6000E+02	6.5000E+02	1.3826E+02	1.3826E+02	.0000E+00	.0000E+00	8.0000E-03
360	1.0800E+03	6.5000E+02	1.3826E+02	1.3826E+02	.0000E+00	.0000E+00	9.0000E-03
400	1.2000E+03	6.5000E+02	1.3826E+02	1.3826E+02	.0000E+00	.0000E+00	1.0000E-02
440	1.3200E+03	6.5000E+02	1.3826E+02	1.3826E+02	.0000E+00	.0000E+00	1.1000E-02
480	1.4400E+03	6.5000E+02	1.3826E+02	1.3826E+02	.0000E+00	.0000E+00	1.2000E-02
520	1.5600E+03	6.5000E+02	1.3826E+02	1.3826E+02	.0000E+00	.0000E+00	1.3000E-02
560	1.6800E+03	6.5000E+02	1.3826E+02	1.3826E+02	.0000E+00	.0000E+00	1.4000E-02
600	1.8000E+03	6.5000E+02	1.3826E+02	1.3826E+02	.0000E+00	.0000E+00	1.5000E-02
640	1.9200E+03	6.5000E+02	1.3826E+02	1.3826E+02	.0000E+00	.0000E+00	1.6000E-02
680	2.0400E+03	6.5000E+02	1.3826E+02	1.3826E+02	.0000E+00	.0000E+00	1.7000E-02
720	2.1600E+03	6.5000E+02	1.3826E+02	1.3826E+02	.0000E+00	.0000E+00	1.8000E-02
760	2.2800E+03	6.5000E+02	1.3826E+02	1.3826E+02	.0000E+00	.0000E+00	1.9000E-02
800	2.4000E+03	6.5000E+02	1.3826E+02	1.3826E+02	.0000E+00	.0000E+00	2.0000E-02
840	2.5200E+03	6.5000E+02	1.3826E+02	1.3826E+02	.0000E+00	.0000E+00	2.1000E-02
880	2.6400E+03	6.5000E+02	1.3826E+02	1.3826E+02	.0000E+00	.0000E+00	2.2000E-02
920	2.7600E+03	6.5000E+02	1.3826E+02	1.3826E+02	.0000E+00	.0000E+00	2.3000E-02
960	2.8800E+03	6.5000E+02	1.3826E+02	1.3826E+02	.0000E+00	.0000E+00	2.4000E-02
1000	3.0000E+03	6.5000E+02	1.3826E+02	1.3826E+02	.0000E+00	.0000E+00	2.5000E-02
1040	3.1200E+03	6.5000E+02	1.3826E+02	1.3826E+02	.0000E+00	.0000E+00	2.6000E-02
1080	3.2400E+03	6.5000E+02	1.3826E+02	1.3826E+02	.0000E+00	.0000E+00	2.7000E-02
1120	3.3600E+03	6.5000E+02	1.3826E+02	1.3826E+02	.0000E+00	.0000E+00	2.8000E-02
1160	3.4800E+03	6.5000E+02	1.3826E+02	1.3826E+02	.0000E+00	.0000E+00	2.9000E-02
1200	3.6000E+03	6.5000E+02	1.3826E+02	1.3826E+02	.0000E+00	.0000E+00	3.0000E-02
1240	3.7200E+03	6.5000E+02	1.3826E+02	1.3826E+02	.0000E+00	.0000E+00	3.1000E-02
1280	3.8400E+03	6.5000E+02	1.3826E+02	1.3826E+02	.0000E+00	.0000E+00	3.2000E-02
1320	3.9600E+03	6.5000E+02	1.3826E+02	1.3826E+02	.0000E+00	.0000E+00	3.3000E-02
1360	4.0800E+03	6.5000E+02	1.3826E+02	1.3826E+02	.0000E+00	.0000E+00	3.4000E-02
1400	4.2000E+03	6.5000E+02	1.3826E+02	1.3826E+02	.0000E+00	.0000E+00	3.5000E-02
1440	4.3200E+03	6.5000E+02	1.3826E+02	1.3826E+02	.0000E+00	.0000E+00	3.6000E-02
1480	4.4400E+03	6.5000E+02	1.3826E+02	1.3826E+02	.0000E+00	.0000E+00	3.7000E-02
1520	4.5600E+03	6.5000E+02	1.3826E+02	1.3826E+02	.0000E+00	.0000E+00	3.8000E-02
1560	4.6800E+03	6.5000E+02	1.3826E+02	1.3826E+02	.0000E+00	.0000E+00	3.9000E-02
1600	4.8000E+03	6.5000E+02	1.3826E+02	1.3826E+02	.0000E+00	.0000E+00	4.0000E-02

```
    ************************************
    *                                  *
    *   F I D E P 2 - VERSION 6        *
    *                                  *
    ************************************

  ************ PROBLEM TITLE ************

Bodner Partom with Dir. Hardening from 650C to 750C

  ************ GEOMETRY TYPE ************

     1-D Laminate Model

  ************ LOADING TYPE ************

      Strain Control

  ********* LOADING HISTORY ************

  POINTS IN HISTORY  6

      Step          Time      Temperature  Axial Strain
    .0000E+00    .0000E+00   6.5000E+02    .0000E+00
   1.2000E+03   1.2000E+01   6.5000E+02   1.0000E-02
   1.8000E+03   1.8000E+01   7.6000E+02   1.5000E-02
   2.4000E+03   3.0000E+01   7.6000E+02   2.5000E-02
   3.6000E+03   3.6000E+01   6.5000E+02   3.0000E-02
   4.8000E+03   4.8000E+01   6.5000E+02   4.0000E-02

  ********* GEOMETRY INFORMATION  ***********

  Number of Cells  1

       For Cell Number : 1

            Material Number :  4
            Volume Fraction :  1.0
            Nodes in cell   :  2


  ********** OUTPUT INFORMATION  ************

  Output at Interface for Material:  1


  ********** MATERIAL INFORMATION  ************

  Material for Cell Number :  1

Bodner-Partom Theory with Directional Hardening for TimetalÒ21S

 Constitutive model: Bodner-Partom with Directional Hardening


  -------------------- OUTPUT -------------------
```

STEP	TIME	TEMPERATURE	SZ-APP	SZ-LAM1	SZ-LAM2	SZ-LAM3	ETOT
1	1.0000E-02	6.5000E+02	7.2175E-01	7.2175E-01	.0000E+00	.0000E+00	8.3333E-06
40	4.0000E-01	6.5000E+02	2.8870E+01	2.8870E+01	.0000E+00	.0000E+00	3.3333E-04
80	8.0000E-01	6.5000E+02	5.7740E+01	5.7740E+01	.0000E+00	.0000E+00	6.6667E-04
120	1.2000E+00	6.5000E+02	8.6375E+01	8.6375E+01	.0000E+00	.0000E+00	1.0000E-03
160	1.6000E+00	6.5000E+02	1.0981E+02	1.0981E+02	.0000E+00	.0000E+00	1.3333E-03
200	2.0000E+00	6.5000E+02	1.3309E+02	1.3309E+02	.0000E+00	.0000E+00	1.6667E-03
240	2.4000E+00	6.5000E+02	1.5670E+02	1.5670E+02	.0000E+00	.0000E+00	2.0000E-03
280	2.8000E+00	6.5000E+02	1.8038E+02	1.8038E+02	.0000E+00	.0000E+00	2.3333E-03
320	3.2000E+00	6.5000E+02	2.0388E+02	2.0388E+02	.0000E+00	.0000E+00	2.6667E-03
360	3.6000E+00	6.5000E+02	2.2691E+02	2.2691E+02	.0000E+00	.0000E+00	3.0000E-03
400	4.0000E+00	6.5000E+02	2.4917E+02	2.4917E+02	.0000E+00	.0000E+00	3.3333E-03
440	4.4000E+00	6.5000E+02	2.7032E+02	2.7032E+02	.0000E+00	.0000E+00	3.6667E-03
480	4.8000E+00	6.5000E+02	2.9005E+02	2.9005E+02	.0000E+00	.0000E+00	4.0000E-03
520	5.2000E+00	6.5000E+02	3.0802E+02	3.0802E+02	.0000E+00	.0000E+00	4.3333E-03
560	5.6000E+00	6.5000E+02	3.2396E+02	3.2396E+02	.0000E+00	.0000E+00	4.6667E-03
600	6.0000E+00	6.5000E+02	3.3768E+02	3.3768E+02	.0000E+00	.0000E+00	5.0000E-03
640	6.4000E+00	6.5000E+02	3.4910E+02	3.4910E+02	.0000E+00	.0000E+00	5.3333E-03

680	6.8000E+00	6.5000E+02	3.5828E+02	3.5828E+02	.0000E+00	.0000E+00	5.6667E-03
720	7.2000E+00	6.5000E+02	3.6542E+02	3.6542E+02	.0000E+00	.0000E+00	6.0000E-03
760	7.6000E+00	6.5000E+02	3.7081E+02	3.7081E+02	.0000E+00	.0000E+00	6.3333E-03
800	8.0000E+00	6.5000E+02	3.7476E+02	3.7476E+02	.0000E+00	.0000E+00	6.6667E-03
840	8.4000E+00	6.5000E+02	3.7760E+02	3.7760E+02	.0000E+00	.0000E+00	7.0000E-03
880	8.8000E+00	6.5000E+02	3.7960E+02	3.7960E+02	.0000E+00	.0000E+00	7.3333E-03
920	9.2000E+00	6.5000E+02	3.8100E+02	3.8100E+02	.0000E+00	.0000E+00	7.6667E-03
960	9.6000E+00	6.5000E+02	3.8196E+02	3.8196E+02	.0000E+00	.0000E+00	8.0000E-03
1000	1.0000E+01	6.5000E+02	3.8262E+02	3.8262E+02	.0000E+00	.0000E+00	8.3333E-03
1040	1.0400E+01	6.5000E+02	3.8308E+02	3.8308E+02	.0000E+00	.0000E+00	8.6667E-03
1080	1.0800E+01	6.5000E+02	3.8338E+02	3.8338E+02	.0000E+00	.0000E+00	9.0000E-03
1120	1.1200E+01	6.5000E+02	3.8359E+02	3.8359E+02	.0000E+00	.0000E+00	9.3333E-03
1160	1.1600E+01	6.5000E+02	3.8373E+02	3.8373E+02	.0000E+00	.0000E+00	9.6667E-03
1200	1.2000E+01	6.5000E+02	3.8383E+02	3.8383E+02	.0000E+00	.0000E+00	1.0000E-02
1240	1.2400E+01	6.5733E+02	3.7163E+02	3.7163E+02	.0000E+00	.0000E+00	1.0333E-02
1280	1.2800E+01	6.6467E+02	3.5666E+02	3.5666E+02	.0000E+00	.0000E+00	1.0667E-02
1320	1.3200E+01	6.7200E+02	3.3994E+02	3.3994E+02	.0000E+00	.0000E+00	1.1000E-02
1360	1.3600E+01	6.7933E+02	3.2223E+02	3.2223E+02	.0000E+00	.0000E+00	1.1333E-02
1400	1.4000E+01	6.8667E+02	3.0406E+02	3.0406E+02	.0000E+00	.0000E+00	1.1667E-02
1440	1.4400E+01	6.9400E+02	2.8576E+02	2.8576E+02	.0000E+00	.0000E+00	1.2000E-02
1480	1.4800E+01	7.0133E+02	2.6758E+02	2.6758E+02	.0000E+00	.0000E+00	1.2333E-02
1520	1.5200E+01	7.0867E+02	2.4966E+02	2.4966E+02	.0000E+00	.0000E+00	1.2667E-02
1560	1.5600E+01	7.1600E+02	2.3210E+02	2.3210E+02	.0000E+00	.0000E+00	1.3000E-02
1600	1.6000E+01	7.2333E+02	2.1499E+02	2.1499E+02	.0000E+00	.0000E+00	1.3333E-02
1640	1.6400E+01	7.3067E+02	1.9839E+02	1.9839E+02	.0000E+00	.0000E+00	1.3667E-02
1680	1.6800E+01	7.3800E+02	1.8237E+02	1.8237E+02	.0000E+00	.0000E+00	1.4000E-02
1720	1.7200E+01	7.4533E+02	1.6696E+02	1.6696E+02	.0000E+00	.0000E+00	1.4333E-02
1760	1.7600E+01	7.5267E+02	1.5221E+02	1.5221E+02	.0000E+00	.0000E+00	1.4667E-02
1800	1.8000E+01	7.6000E+02	1.3817E+02	1.3817E+02	.0000E+00	.0000E+00	1.5000E-02
1840	1.8800E+01	7.6000E+02	1.3163E+02	1.3163E+02	.0000E+00	.0000E+00	1.5667E-02
1880	1.9600E+01	7.6000E+02	1.2955E+02	1.2955E+02	.0000E+00	.0000E+00	1.6333E-02
1920	2.0400E+01	7.6000E+02	1.2885E+02	1.2885E+02	.0000E+00	.0000E+00	1.7000E-02
1960	2.1200E+01	7.6000E+02	1.2861E+02	1.2861E+02	.0000E+00	.0000E+00	1.7667E-02
2000	2.2000E+01	7.6000E+02	1.2853E+02	1.2853E+02	.0000E+00	.0000E+00	1.8333E-02
2040	2.2800E+01	7.6000E+02	1.2850E+02	1.2850E+02	.0000E+00	.0000E+00	1.9000E-02
2080	2.3600E+01	7.6000E+02	1.2849E+02	1.2849E+02	.0000E+00	.0000E+00	1.9667E-02
2120	2.4400E+01	7.6000E+02	1.2848E+02	1.2848E+02	.0000E+00	.0000E+00	2.0333E-02
2160	2.5200E+01	7.6000E+02	1.2848E+02	1.2848E+02	.0000E+00	.0000E+00	2.1000E-02
2200	2.6000E+01	7.6000E+02	1.2848E+02	1.2848E+02	.0000E+00	.0000E+00	2.1667E-02
2240	2.6800E+01	7.6000E+02	1.2848E+02	1.2848E+02	.0000E+00	.0000E+00	2.2333E-02
2280	2.7600E+01	7.6000E+02	1.2848E+02	1.2848E+02	.0000E+00	.0000E+00	2.3000E-02
2320	2.8400E+01	7.6000E+02	1.2848E+02	1.2848E+02	.0000E+00	.0000E+00	2.3667E-02
2360	2.9200E+01	7.6000E+02	1.2848E+02	1.2848E+02	.0000E+00	.0000E+00	2.4333E-02
2400	3.0000E+01	7.6000E+02	1.2848E+02	1.2848E+02	.0000E+00	.0000E+00	2.5000E-02
2440	3.0200E+01	7.5633E+02	1.3269E+02	1.3269E+02	.0000E+00	.0000E+00	2.5167E-02
2480	3.0400E+01	7.5267E+02	1.3736E+02	1.3736E+02	.0000E+00	.0000E+00	2.5333E-02
2520	3.0600E+01	7.4900E+02	1.4245E+02	1.4245E+02	.0000E+00	.0000E+00	2.5500E-02
2560	3.0800E+01	7.4533E+02	1.4786E+02	1.4786E+02	.0000E+00	.0000E+00	2.5667E-02
2600	3.1000E+01	7.4167E+02	1.5357E+02	1.5357E+02	.0000E+00	.0000E+00	2.5833E-02
2640	3.1200E+01	7.3800E+02	1.5954E+02	1.5954E+02	.0000E+00	.0000E+00	2.6000E-02
2680	3.1400E+01	7.3433E+02	1.6574E+02	1.6574E+02	.0000E+00	.0000E+00	2.6167E-02
2720	3.1600E+01	7.3067E+02	1.7216E+02	1.7216E+02	.0000E+00	.0000E+00	2.6333E-02
2760	3.1800E+01	7.2700E+02	1.7878E+02	1.7878E+02	.0000E+00	.0000E+00	2.6500E-02
2800	3.2000E+01	7.2333E+02	1.8558E+02	1.8558E+02	.0000E+00	.0000E+00	2.6667E-02
2840	3.2200E+01	7.1967E+02	1.9256E+02	1.9256E+02	.0000E+00	.0000E+00	2.6833E-02
2880	3.2400E+01	7.1600E+02	1.9972E+02	1.9972E+02	.0000E+00	.0000E+00	2.7000E-02
2920	3.2600E+01	7.1233E+02	2.0704E+02	2.0704E+02	.0000E+00	.0000E+00	2.7167E-02
2960	3.2800E+01	7.0867E+02	2.1453E+02	2.1453E+02	.0000E+00	.0000E+00	2.7333E-02
3000	3.3000E+01	7.0500E+02	2.2217E+02	2.2217E+02	.0000E+00	.0000E+00	2.7500E-02
3040	3.3200E+01	7.0133E+02	2.2997E+02	2.2997E+02	.0000E+00	.0000E+00	2.7667E-02
3080	3.3400E+01	6.9767E+02	2.3791E+02	2.3791E+02	.0000E+00	.0000E+00	2.7833E-02
3120	3.3600E+01	6.9400E+02	2.4601E+02	2.4601E+02	.0000E+00	.0000E+00	2.8000E-02
3160	3.3800E+01	6.9033E+02	2.5424E+02	2.5424E+02	.0000E+00	.0000E+00	2.8167E-02
3200	3.4000E+01	6.8667E+02	2.6262E+02	2.6262E+02	.0000E+00	.0000E+00	2.8333E-02
3240	3.4200E+01	6.8300E+02	2.7114E+02	2.7114E+02	.0000E+00	.0000E+00	2.8500E-02
3280	3.4400E+01	6.7933E+02	2.7979E+02	2.7979E+02	.0000E+00	.0000E+00	2.8667E-02
3320	3.4600E+01	6.7567E+02	2.8857E+02	2.8857E+02	.0000E+00	.0000E+00	2.8833E-02
3360	3.4800E+01	6.7200E+02	2.9749E+02	2.9749E+02	.0000E+00	.0000E+00	2.9000E-02
3400	3.5000E+01	6.6833E+02	3.0653E+02	3.0653E+02	.0000E+00	.0000E+00	2.9167E-02
3440	3.5200E+01	6.6467E+02	3.1570E+02	3.1570E+02	.0000E+00	.0000E+00	2.9333E-02
3480	3.5400E+01	6.6100E+02	3.2500E+02	3.2500E+02	.0000E+00	.0000E+00	2.9500E-02
3520	3.5600E+01	6.5733E+02	3.3441E+02	3.3441E+02	.0000E+00	.0000E+00	2.9667E-02
3560	3.5800E+01	6.5367E+02	3.4393E+02	3.4393E+02	.0000E+00	.0000E+00	2.9833E-02
3600	3.6000E+01	6.5000E+02	3.5357E+02	3.5357E+02	.0000E+00	.0000E+00	3.0000E-02
3640	3.6400E+01	6.5000E+02	3.6182E+02	3.6182E+02	.0000E+00	.0000E+00	3.0333E-02
3680	3.6800E+01	6.5000E+02	3.6812E+02	3.6812E+02	.0000E+00	.0000E+00	3.0667E-02
3720	3.7200E+01	6.5000E+02	3.7281E+02	3.7281E+02	.0000E+00	.0000E+00	3.1000E-02
3760	3.7600E+01	6.5000E+02	3.7622E+02	3.7622E+02	.0000E+00	.0000E+00	3.1333E-02
3800	3.8000E+01	6.5000E+02	3.7864E+02	3.7864E+02	.0000E+00	.0000E+00	3.1667E-02
3840	3.8400E+01	6.5000E+02	3.8034E+02	3.8034E+02	.0000E+00	.0000E+00	3.2000E-02
3880	3.8800E+01	6.5000E+02	3.8153E+02	3.8153E+02	.0000E+00	.0000E+00	3.2333E-02
3920	3.9200E+01	6.5000E+02	3.8234E+02	3.8234E+02	.0000E+00	.0000E+00	3.2667E-02
3960	3.9600E+01	6.5000E+02	3.8289E+02	3.8289E+02	.0000E+00	.0000E+00	3.3000E-02
4000	4.0000E+01	6.5000E+02	3.8327E+02	3.8327E+02	.0000E+00	.0000E+00	3.3333E-02
4040	4.0400E+01	6.5000E+02	3.8353E+02	3.8353E+02	.0000E+00	.0000E+00	3.3667E-02
4080	4.0800E+01	6.5000E+02	3.8371E+02	3.8371E+02	.0000E+00	.0000E+00	3.4000E-02

4120	4.1200E+01	6.5000E+02	3.8382E+02	3.8382E+02	.0000E+00	.0000E+00	3.4333E-02
4160	4.1600E+01	6.5000E+02	3.8390E+02	3.8390E+02	.0000E+00	.0000E+00	3.4667E-02
4200	4.2000E+01	6.5000E+02	3.8396E+02	3.8396E+02	.0000E+00	.0000E+00	3.5000E-02
4240	4.2400E+01	6.5000E+02	3.8400E+02	3.8400E+02	.0000E+00	.0000E+00	3.5333E-02
4280	4.2800E+01	6.5000E+02	3.8402E+02	3.8402E+02	.0000E+00	.0000E+00	3.5667E-02
4320	4.3200E+01	6.5000E+02	3.8404E+02	3.8404E+02	.0000E+00	.0000E+00	3.6000E-02
4360	4.3600E+01	6.5000E+02	3.8405E+02	3.8405E+02	.0000E+00	.0000E+00	3.6333E-02
4400	4.4000E+01	6.5000E+02	3.8406E+02	3.8406E+02	.0000E+00	.0000E+00	3.6667E-02
4440	4.4400E+01	6.5000E+02	3.8406E+02	3.8406E+02	.0000E+00	.0000E+00	3.7000E-02
4480	4.4800E+01	6.5000E+02	3.8407E+02	3.8407E+02	.0000E+00	.0000E+00	3.7333E-02
4520	4.5200E+01	6.5000E+02	3.8407E+02	3.8407E+02	.0000E+00	.0000E+00	3.7667E-02
4560	4.5600E+01	6.5000E+02	3.8407E+02	3.8407E+02	.0000E+00	.0000E+00	3.8000E-02
4600	4.6000E+01	6.5000E+02	3.8407E+02	3.8407E+02	.0000E+00	.0000E+00	3.8333E-02
4640	4.6400E+01	6.5000E+02	3.8407E+02	3.8407E+02	.0000E+00	.0000E+00	3.8667E-02
4680	4.6800E+01	6.5000E+02	3.8407E+02	3.8407E+02	.0000E+00	.0000E+00	3.9000E-02
4720	4.7200E+01	6.5000E+02	3.8407E+02	3.8407E+02	.0000E+00	.0000E+00	3.9333E-02
4760	4.7600E+01	6.5000E+02	3.8407E+02	3.8407E+02	.0000E+00	.0000E+00	3.9667E-02
4800	4.8000E+01	6.5000E+02	3.8407E+02	3.8407E+02	.0000E+00	.0000E+00	4.0000E-02

0

```
      ************************************
      *                                  *
      *   F I D E P 2 - VERSION 6        *
      *                                  *
      ************************************


  ************ PROBLEM TITLE ************

SCS-6/TIMETAL21S(EP) Concentric Cylinder cooled from 900C to 23C

  ************ GEOMETRY TYPE ************

     Concentric Cylinder Model

  ************ LOADING TYPE ************

      Stress Control

  ********* LOADING HISTORY ************

  POINTS IN HISTORY  2

      Step          Time      Temperature  Axial Stress  Radial Stress
     .0000E+00    .0000E+00   9.0000E+02    .0000E+00    .0000E+00
    3.6000E+02   3.6000E+03   2.5000E+01    .0000E+00    .0000E+00

  ********* GEOMETRY INFORMATION  ***********

  Number of Cells  2

       For Cell Number : 1

            Material Number :  1
            Volume Fraction :  .35
            Nodes in cell   :  5

       For Cell Number : 2

            Material Number :  2
            Volume Fraction :  .65
            Nodes in cell   :  15

********** OUTPUT INFORMATION  ************

  Output at Interface for Material:  2

  ********** MATERIAL INFORMATION  ************

  Material for Cell Number :  1

   Thermo-Elastic Response for SCS-6 fiber

  Constitutive model: Elastic
  ---------- MATERIAL PROPERTIES  ----------

     T(C)         E(GPa)        NU         CTE(1E-6/C)
   2.1110E+01   3.9300E+02   2.5000E-01   3.9907E+00
   9.3330E+01   3.9000E+02   2.5000E-01   4.0289E+00
   2.0444E+02   3.8600E+02   2.5000E-01   4.0989E+00
```

3.1556E+02	3.8200E+02	2.5000E-01	4.1801E+00
4.2667E+02	3.7800E+02	2.5000E-01	4.2655E+00
5.3778E+02	3.7400E+02	2.5000E-01	4.3510E+00
6.4889E+02	3.7000E+02	2.5000E-01	4.4324E+00
7.6000E+02	3.6500E+02	2.5000E-01	4.5074E+00
8.7111E+02	3.6100E+02	2.5000E-01	4.5718E+00
1.0933E+03	3.5400E+02	2.5000E-01	4.5723E+00

Reference Temperature = 900.0

Material for Cell Number : 2

Bilinear Elastic-Plastic Response for TimetalÒ21S

Constitutive model: Bilinear Elastic-Plastic

---------- MATERIAL PROPERTIES ----------

T(C)	E(GPa)	NU	CTE(1E-6/C)
2.3000E+01	1.1400E+02	3.4000E-01	9.7699E+00
2.6000E+02	1.1400E+02	3.4000E-01	1.0719E+01
4.8200E+02	9.0000E+01	3.4000E-01	1.1499E+01
6.5000E+02	7.8000E+01	3.4000E-01	1.2027E+01
7.6000E+02	7.0000E+01	3.4000E-01	1.2344E+01
8.1500E+02	6.4000E+01	3.4000E-01	1.2493E+01
9.0000E+02	5.5000E+01	3.4000E-01	1.3796E+01

Reference Temperature = 900.0

T(C)	SY(MPa)	EP(GPa)
2.3000E+01	1.1070E+03	4.5900E-01
2.6000E+02	1.0100E+03	1.4860E+00
4.8200E+02	8.1000E+02	2.0000E+00
6.5000E+02	3.5000E+02	.0000E+00
7.6000E+02	1.2000E+02	.0000E+00
8.1500E+02	1.1000E+02	.0000E+00
9.0000E+02	9.4000E+01	.0000E+00

-------------------- OUTPUT --------------------

STEP	TIME	TEMPERATRE	Seff	Srad	Stan	Sz	Erad	Etan	Ez
1	1.0000E+01	8.9757E+02	1.9956E+00	-6.8121E-01	1.4153E+00	1.1952E+00	-2.8391E-05	2.2451E-05	1.7113E-05
10	1.0000E+02	8.7569E+02	1.9963E+01	-6.8244E+00	1.4179E+01	1.1904E+01	-2.7257E-04	2.1627E-04	1.6334E-04
20	2.0000E+02	8.5139E+02	3.9857E+01	-1.3646E+01	2.8351E+01	2.3655E+01	-5.2085E-04	4.1479E-04	3.1015E-04
30	3.0000E+02	8.2708E+02	5.9488E+01	-2.0397E+01	4.2378E+01	3.5140E+01	-7.4542E-04	5.9574E-04	4.4111E-04
40	4.0000E+02	8.0278E+02	8.0244E+01	-2.7555E+01	5.7249E+01	4.7179E+01	-9.6521E-04	7.7413E-04	5.6760E-04
50	5.0000E+02	7.7847E+02	1.0331E+02	-3.5525E+01	7.3809E+01	6.0453E+01	-1.1940E-03	9.6101E-04	6.9776E-04
60	6.0000E+02	7.5417E+02	1.2666E+02	-4.3762E+01	9.0452E+01	7.3675E+01	-1.4225E-03	1.1452E-03	8.2424E-04
70	7.0000E+02	7.2986E+02	1.5018E+02	-5.1909E+01	1.0737E+02	8.7123E+01	-1.6437E-03	1.3266E-03	9.4914E-04
80	8.0000E+02	7.0556E+02	1.7430E+02	-6.0276E+01	1.2474E+02	1.0085E+02	-1.8607E-03	1.5053E-03	1.0707E-03
90	9.0000E+02	6.8125E+02	1.9900E+02	-6.8856E+01	1.4255E+02	1.1483E+02	-2.0736E-03	1.6813E-03	1.1889E-03
100	1.0000E+03	6.5694E+02	2.2425E+02	-7.7641E+01	1.6079E+02	1.2905E+02	-2.2823E-03	1.8545E-03	1.3040E-03
110	1.1000E+03	6.3264E+02	2.4984E+02	-8.6555E+01	1.7930E+02	1.4339E+02	-2.4856E-03	2.0241E-03	1.4151E-03
120	1.2000E+03	6.0833E+02	2.7582E+02	-9.5615E+01	1.9811E+02	1.5787E+02	-2.6842E-03	2.1904E-03	1.5228E-03
130	1.3000E+03	5.8403E+02	3.0222E+02	-1.0484E+02	2.1726E+02	1.7253E+02	-2.8785E-03	2.3537E-03	1.6272E-03
140	1.4000E+03	5.5972E+02	3.2903E+02	-1.1421E+02	2.3672E+02	1.8733E+02	-3.0684E-03	2.5140E-03	1.7285E-03
150	1.5000E+03	5.3542E+02	3.5622E+02	-1.2373E+02	2.5649E+02	2.0228E+02	-3.2542E-03	2.6714E-03	1.8268E-03
160	1.6000E+03	5.1111E+02	3.8382E+02	-1.3340E+02	2.7657E+02	2.1738E+02	-3.4362E-03	2.8262E-03	1.9222E-03
170	1.7000E+03	4.8681E+02	4.1175E+02	-1.4320E+02	2.9693E+02	2.3259E+02	-3.6140E-03	2.9781E-03	2.0148E-03

180	1.8000E+03	4.6250E+02	4.4258E+02	-1.5408E+02	3.1950E+02	2.4906E+02	-3.7802E-03	3.1234E-03	2.0968E-03
190	1.9000E+03	4.3819E+02	4.7455E+02	-1.6538E+02	3.4296E+02	2.6597E+02	-3.9398E-03	3.2644E-03	2.1736E-03
200	2.0000E+03	4.1389E+02	5.0700E+02	-1.7686E+02	3.6681E+02	2.8302E+02	-4.0945E-03	3.4020E-03	2.2470E-03
210	2.1000E+03	3.8958E+02	5.3989E+02	-1.8853E+02	3.9102E+02	3.0019E+02	-4.2445E-03	3.5361E-03	2.3171E-03
220	2.2000E+03	3.6528E+02	5.7319E+02	-2.0035E+02	4.1557E+02	3.1746E+02	-4.3897E-03	3.6668E-03	2.3840E-03
230	2.3000E+03	3.4097E+02	6.0685E+02	-2.1231E+02	4.4041E+02	3.3480E+02	-4.5304E-03	3.7941E-03	2.4477E-03
240	2.4000E+03	3.1667E+02	6.4084E+02	-2.2441E+02	4.6553E+02	3.5220E+02	-4.6664E-03	3.9180E-03	2.5085E-03
250	2.5000E+03	2.9236E+02	6.7502E+02	-2.3660E+02	4.9083E+02	3.6959E+02	-4.7973E-03	4.0379E-03	2.5659E-03
260	2.6000E+03	2.6806E+02	7.0944E+02	-2.4888E+02	5.1634E+02	3.8698E+02	-4.9236E-03	4.1543E-03	2.6204E-03
270	2.7000E+03	2.4375E+02	7.3339E+02	-2.5734E+02	5.3389E+02	3.9966E+02	-5.0504E-03	4.2640E-03	2.6845E-03
280	2.8000E+03	2.1944E+02	7.5153E+02	-2.6367E+02	5.4705E+02	4.0972E+02	-5.1752E-03	4.3684E-03	2.7524E-03
290	2.9000E+03	1.9514E+02	7.6890E+02	-2.6973E+02	5.5965E+02	4.1937E+02	-5.2947E-03	4.4682E-03	2.8175E-03
300	3.0000E+03	1.7083E+02	7.8543E+02	-2.7550E+02	5.7163E+02	4.2856E+02	-5.4084E-03	4.5630E-03	2.8796E-03
310	3.1000E+03	1.4653E+02	8.0128E+02	-2.8103E+02	5.8311E+02	4.3739E+02	-5.5175E-03	4.6539E-03	2.9393E-03
320	3.2000E+03	1.2222E+02	8.1645E+02	-2.8632E+02	5.9410E+02	4.4585E+02	-5.6219E-03	4.7408E-03	2.9965E-03
330	3.3000E+03	9.7917E+01	8.3095E+02	-2.9137E+02	6.0460E+02	4.5396E+02	-5.7217E-03	4.8238E-03	3.0514E-03
340	3.4000E+03	7.3611E+01	8.4452E+02	-2.9609E+02	6.1441E+02	4.6158E+02	-5.8151E-03	4.9012E-03	3.1031E-03
350	3.5000E+03	4.9306E+01	8.5733E+02	-3.0055E+02	6.2367E+02	4.6880E+02	-5.9033E-03	4.9742E-03	3.1521E-03
360	3.6000E+03	2.5000E+01	8.6945E+02	-3.0476E+02	6.3241E+02	4.7565E+02	-5.9868E-03	5.0430E-03	3.1986E-03

Cross-Sectional Results at Step 360
time = 3600.0000

Radius	Seff	Srad	Stan	Sz	Er	Etan	Ez
.000	5.7882E+02	-3.0476E+02	-3.0476E+02	-8.8441E+02	-1.9004E-05	-1.9004E-05	-1.8634E-03
.148	5.7882E+02	-3.0476E+02	-3.0476E+02	-8.8441E+02	-1.9004E-05	-1.9004E-05	-1.8634E-03
.296	5.7882E+02	-3.0476E+02	-3.0476E+02	-8.8441E+02	-1.9004E-05	-1.9004E-05	-1.8634E-03
.444	5.7882E+02	-3.0476E+02	-3.0476E+02	-8.8441E+02	-1.9004E-05	-1.9004E-05	-1.8634E-03
.592	5.7882E+02	-3.0476E+02	-3.0476E+02	-8.8441E+02	-1.9004E-05	-1.9004E-05	-1.8634E-03
.592	8.6945E+02	-3.0476E+02	6.3241E+02	4.7565E+02	-5.9868E-03	5.0430E-03	3.1986E-03
.621	8.0095E+02	-2.6171E+02	5.9004E+02	4.7627E+02	-5.4760E-03	4.5359E-03	3.1986E-03
.650	7.4168E+02	-2.2433E+02	5.5256E+02	4.7624E+02	-5.0361E-03	4.0957E-03	3.1986E-03
.679	6.9071E+02	-1.9166E+02	5.1982E+02	4.7622E+02	-4.6519E-03	3.7112E-03	3.1986E-03
.708	6.4670E+02	-1.6295E+02	4.9106E+02	4.7620E+02	-4.3142E-03	3.3733E-03	3.1986E-03
.737	6.0856E+02	-1.3758E+02	4.6564E+02	4.7618E+02	-4.0158E-03	3.0747E-03	3.1986E-03
.767	5.7540E+02	-1.1506E+02	4.4308E+02	4.7617E+02	-3.7509E-03	2.8097E-03	3.1986E-03
.796	5.4647E+02	-9.4968E+01	4.2296E+02	4.7616E+02	-3.5146E-03	2.5733E-03	3.1986E-03
.825	5.2118E+02	-7.6973E+01	4.0494E+02	4.7615E+02	-3.3030E-03	2.3616E-03	3.1986E-03
.854	4.9900E+02	-6.0791E+01	3.8873E+02	4.7614E+02	-3.1127E-03	2.1712E-03	3.1986E-03
.883	4.7952E+02	-4.6187E+01	3.7411E+02	4.7614E+02	-2.9410E-03	1.9994E-03	3.1986E-03
.912	4.6237E+02	-3.2963E+01	3.6087E+02	4.7613E+02	-2.7855E-03	1.8438E-03	3.1986E-03
.942	4.4723E+02	-2.0949E+01	3.4884E+02	4.7613E+02	-2.6442E-03	1.7025E-03	3.1986E-03
.971	4.3385E+02	-1.0002E+01	3.3788E+02	4.7612E+02	-2.5155E-03	1.5737E-03	3.1986E-03
1.000	4.2200E+02	.0000E+00	3.2787E+02	4.7612E+02	-2.3979E-03	1.4561E-03	3.1986E-03

```
    ************************************
    *                                  *
    *   F I D E P 2 - VERSION 6        *
    *                                  *
    ************************************

  ************ PROBLEM TITLE ************

SCS-6/TIMETAL21S(EP) Concentric Cylinder cooled from 900C to 23C

  --------- Average Stress Output ----------
```

STEP	TIME	TEMPERATURE	SZAPP	SZF	SZM	SZ90	EME-F	EME-M	EME-90	EZC
1	1.0000E+01	8.9757E+02	.0000E+00	-2.2193E+00	1.1950E+00	.0000E+00	-5.2163E-06	1.7113E-05	.0000E+00	-1.6328E-05
10	1.0000E+02	8.7569E+02	.0000E+00	-2.2105E+01	1.1903E+01	0000E+00	-5.1801E-05	1.6334E-04	.0000E+00	-1.6292E-04
20	2.0000E+02	8.5139E+02	.0000E+00	-4.3924E+01	2.3651E+01	.0000E+00	-1.0257E-04	3.1015E-04	.0000E+00	-3.2426E-04
30	3.0000E+02	8.2708E+02	.0000E+00	-6.5251E+01	3.5135E+01	.0000E+00	-1.5183E-04	4.4111E-04	.0000E+00	-4.8333E-04
40	4.0000E+02	8.0278E+02	.0000E+00	-8.7606E+01	4.7173E+01	.0000E+00	-2.0313E-04	5.6760E-04	.0000E+00	-6.4376E-04
50	5.0000E+02	7.7847E+02	.0000E+00	-1.1225E+02	6.0445E+01	.0000E+00	-2.5935E-04	6.9776E-04	.0000E+00	-8.0843E-04
60	6.0000E+02	7.5417E+02	.0000E+00	-1.3755E+02	7.4064E+01	.0000E+00	-3.1667E-04	8.2424E-04	.0000E+00	-9.7342E-04
70	7.0000E+02	7.2986E+02	.0000E+00	-1.6254E+02	8.7520E+01	.0000E+00	-3.7281E-04	9.4914E-04	.0000E+00	-1.1362E-03
80	**8.0000E+02**	**7.0556E+02**	**.0000E+00**	**-1.8804E+02**	**1.0125E+02**	**.0000E+00**	**-4.2971E-04**	**1.0707E-03**	**.0000E+00**	**-1.2990E-03**
90	9.0000E+02	6.8125E+02	.0000E+00	-2.1402E+02	1.1524E+02	.0000E+00	-4.8729E-04	1.1889E-03	.0000E+00	-1.4617E-03
100	1.0000E+03	6.5694E+02	.0000E+00	-2.4045E+02	1.2947E+02	.0000E+00	-5.4548E-04	1.3040E-03	.0000E+00	-1.6241E-03
110	1.1000E+03	6.3264E+02	.0000E+00	-2.6710E+02	1.4382E+02	.0000E+00	-6.0396E-04	1.4151E-03	.0000E+00	-1.7858E-03
120	1.2000E+03	6.0833E+02	.0000E+00	-2.9401E+02	1.5831E+02	.0000E+00	-6.6278E-04	1.5228E-03	.0000E+00	-1.9469E-03
130	1.3000E+03	5.8403E+02	.0000E+00	-3.2123E+02	1.7297E+02	.0000E+00	-7.2196E-04	1.6272E-03	.0000E+00	-2.1075E-03
140	1.4000E+03	5.5972E+02	.0000E+00	-3.4874E+02	1.8778E+02	.0000E+00	-7.8141E-04	1.7285E-03	.0000E+00	-2.2674E-03
150	1.5000E+03	5.3542E+02	.0000E+00	-3.7651E+02	2.0274E+02	.0000E+00	-8.4111E-04	1.8268E-03	.0000E+00	-2.4267E-03
160	1.6000E+03	5.1111E+02	.0000E+00	-4.0456E+02	2.1784E+02	.0000E+00	-9.0106E-04	1.9222E-03	.0000E+00	-2.5851E-03
170	1.7000E+03	4.8681E+02	.0000E+00	-4.3283E+02	2.3306E+02	.0000E+00	-9.6114E-04	2.0148E-03	.0000E+00	-2.7427E-03
180	1.8000E+03	4.6250E+02	.0000E+00	-4.6344E+02	2.4954E+02	.0000E+00	-1.0257E-03	2.0968E-03	.0000E+00	-2.9039E-03
190	1.9000E+03	4.3819E+02	.0000E+00	-4.9486E+02	2.6646E+02	.0000E+00	-1.0916E-03	2.1736E-03	.0000E+00	-3.0655E-03
200	2.0000E+03	4.1389E+02	.0000E+00	-5.2655E+02	2.8353E+02	.0000E+00	-1.1576E-03	2.2470E-03	.0000E+00	-3.2264E-03
210	2.1000E+03	3.8958E+02	.0000E+00	-5.5846E+02	3.0071E+02	.0000E+00	-1.2237E-03	2.3171E-03	.0000E+00	-3.3863E-03
220	2.2000E+03	3.6528E+02	.0000E+00	-5.9055E+02	3.1799E+02	.0000E+00	-1.2898E-03	2.3840E-03	.0000E+00	-3.5454E-03
230	2.3000E+03	3.4097E+02	.0000E+00	-6.2278E+02	3.3535E+02	.0000E+00	-1.3557E-03	2.4477E-03	.0000E+00	-3.7034E-03
240	2.4000E+03	3.1667E+02	.0000E+00	-6.5512E+02	3.5276E+02	.0000E+00	-1.4214E-03	2.5085E-03	.0000E+00	-3.8603E-03
250	2.5000E+03	2.9236E+02	.0000E+00	-6.8743E+02	3.7015E+02	.0000E+00	-1.4866E-03	2.5659E-03	.0000E+00	-4.0163E-03
260	2.6000E+03	2.6806E+02	.0000E+00	-7.1975E+02	3.8756E+02	.0000E+00	-1.5515E-03	2.6204E-03	.0000E+00	-4.1711E-03
270	2.7000E+03	2.4375E+02	.0000E+00	-7.4331E+02	4.0025E+02	.0000E+00	-1.5982E-03	2.6845E-03	.0000E+00	-4.3070E-03
280	2.8000E+03	2.1944E+02	.0000E+00	-7.6199E+02	4.1030E+02	.0000E+00	-1.6348E-03	2.7524E-03	.0000E+00	-4.4318E-03
290	2.9000E+03	1.9514E+02	.0000E+00	-7.7991E+02	4.1995E+02	.0000E+00	-1.6696E-03	2.8175E-03	.0000E+00	-4.5547E-03
300	3.0000E+03	1.7083E+02	.0000E+00	-7.9697E+02	4.2914E+02	.0000E+00	-1.7025E-03	2.8796E-03	.0000E+00	-4.6758E-03
310	3.1000E+03	1.4653E+02	.0000E+00	-8.1336E+02	4.3797E+02	.0000E+00	-1.7338E-03	2.9393E-03	.0000E+00	-4.7947E-03
320	3.2000E+03	1.2222E+02	.0000E+00	-8.2908E+02	4.4643E+02	.0000E+00	-1.7635E-03	2.9965E-03	.0000E+00	-4.9112E-03
330	3.3000E+03	9.7917E+01	.0000E+00	-8.4413E+02	4.5453E+02	.0000E+00	-1.7916E-03	3.0514E-03	.0000E+00	-5.0255E-03
340	3.4000E+03	7.3611E+01	.0000E+00	-8.5829E+02	4.6215E+02	.0000E+00	-1.8173E-03	3.1031E-03	.0000E+00	-5.1381E-03
350	3.5000E+03	4.9306E+01	.0000E+00	-8.7170E+02	4.6937E+02	.0000E+00	-1.8412E-03	3.1521E-03	.0000E+00	-5.2487E-03
360	3.6000E+03	2.5000E+01	.0000E+00	-8.8441E+02	4.7622E+02	.0000E+00	-1.8634E-03	3.1986E-03	.0000E+00	-5.3571E-03

```
      ************************************
      *                                  *
      *   F I D E P 2 - VERSION 6        *
      *                                  *
      ************************************


  ************ PROBLEM TITLE ************

SCS-6/TIMETAL21S(DBP) Concentric Cylinder cooled from 900C to 23C

  ************ GEOMETRY TYPE ************

     Concentric Cylinder Model

  ************ LOADING TYPE ************

      Stress Control

  ********* LOADING HISTORY ************

  POINTS IN HISTORY  2

      Step          Time      Temperature  Axial Stress  Radial Stress
     .0000E+00    .0000E+00   9.0000E+02    .0000E+00    .0000E+00
    3.6000E+03   3.6000E+03   2.5000E+01    .0000E+00    .0000E+00

  ********* GEOMETRY INFORMATION  ***********

  Number of Cells  2

       For Cell Number : 1

            Material Number :  1
            Volume Fraction :  .35
            Nodes in cell   :  7

       For Cell Number : 2

            Material Number :  4
            Volume Fraction :  .65
            Nodes in cell   :  20

  ********** OUTPUT INFORMATION  ************

  Output at Interface for Material:  2

********** MATERIAL INFORMATION  ************

Material for Cell Number :  1

   Thermo-Elastic Response for SCS-6 fiber

  Constitutive model: Elastic


  ---------- MATERIAL PROPERTIES  ----------

     T(C)        E(GPa)       NU        CTE(1E-6/C)
   2.1110E+01   3.9300E+02   2.5000E-01   3.9907E+00
```

9.3330E+01	3.9000E+02	2.5000E-01	4.0289E+00
2.0444E+02	3.8600E+02	2.5000E-01	4.0989E+00
3.1556E+02	3.8200E+02	2.5000E-01	4.1801E+00
4.2667E+02	3.7800E+02	2.5000E-01	4.2655E+00
5.3778E+02	3.7400E+02	2.5000E-01	4.3510E+00
6.4889E+02	3.7000E+02	2.5000E-01	4.4324E+00
7.6000E+02	3.6500E+02	2.5000E-01	4.5074E+00
8.7111E+02	3.6100E+02	2.5000E-01	4.5718E+00
1.0933E+03	3.5400E+02	2.5000E-01	4.5723E+00

Reference Temperature = 900.0

Material for Cell Number : 2

Bodner-Partom Theory with Directional Hardening for TimetalÒ21S

Constitutive model: Bodner-Partom with Directional Hardening

---------- MATERIAL PROPERTIES ----------

T(C)	E(GPa)	NU	CTE(1E-6/C)
2.3000E+01	1.1200E+02	3.4000E-01	9.7787E+00
2.6000E+02	1.0800E+02	3.4000E-01	1.0713E+01
3.1500E+02	1.0610E+02	3.4000E-01	1.0915E+01
3.6500E+02	1.0410E+02	3.4000E-01	1.1093E+01
4.1500E+02	1.0170E+02	3.4000E-01	1.1267E+01
4.6500E+02	9.9090E+01	3.4000E-01	1.1436E+01
4.8200E+02	9.8110E+01	3.4000E-01	1.1492E+01
5.0000E+02	9.7050E+01	3.4000E-01	1.1550E+01
5.2500E+02	9.5500E+01	3.4000E-01	1.1631E+01
5.5000E+02	9.3870E+01	3.4000E-01	1.1710E+01
5.7500E+02	9.2170E+01	3.4000E-01	1.1788E+01
6.0000E+02	9.0400E+01	3.4000E-01	1.1865E+01
6.5000E+02	8.6610E+01	3.4000E-01	1.2014E+01
7.6000E+02	7.7220E+01	3.4000E-01	1.2323E+01
8.1500E+02	7.1960E+01	3.4000E-01	1.2467E+01
9.0000E+02	6.3120E+01	3.4000E-01	1.2689E+01

Reference Temperature = 900.0

T(C)	N	Z0=Z2(1/S)	Z3(MPa)	M2(1/MPa)
2.3000E+01	4.8000E+00	1.5500E+03	1.0000E+02	3.5000E-01
2.6000E+02	3.5000E+00	1.3000E+03	3.0000E+02	3.5000E-01
3.1500E+02	3.0540E+00	1.2504E+03	3.9000E+02	1.5020E+00
3.6500E+02	2.6490E+00	1.2054E+03	5.0000E+02	2.5490E+00
4.1500E+02	2.2430E+00	1.1604E+03	6.6000E+02	3.5970E+00
4.6500E+02	1.8380E+00	1.1153E+03	9.6000E+02	4.6440E+00
4.8200E+02	1.7000E+00	1.1000E+03	1.1000E+03	5.0000E+00
5.0000E+02	1.5000E+00	1.0893E+03	1.3000E+03	5.7630E+00
5.2500E+02	1.2800E+00	1.0744E+03	1.6700E+03	6.8220E+00
5.5000E+02	1.1000E+00	1.0595E+03	2.1000E+03	7.8810E+00
5.7500E+02	9.7000E-01	1.0446E+03	2.6000E+03	8.9410E+00
6.0000E+02	8.2000E-01	1.0298E+03	3.7000E+03	1.0000E+01
6.5000E+02	7.4000E-01	1.0000E+03	3.8000E+03	1.0000E+01
7.6000E+02	5.8000E-01	6.0000E+02	4.0000E+03	1.5000E+01
8.1500E+02	5.5000E-01	3.0000E+02	4.1000E+03	3.0000E+01
9.0000E+02	5.5000E-01	3.0000E+02	4.3000E+03	3.0000E+01

```
   A1=A2      M1          Z1          R1=R2       DO
-9999.0 .0 1600.0 3.0 10000.0
 ----------------------------------------

-------------------- OUTPUT -------------------
```

STEP	TIME	TEMPERATRE	Seff	Srad	Stan	Sz	Erad	Etan	Ez
1	1.0000E+00	8.9976E+02	1.9900E-01	-6.8276E-02	1.4183E-01	1.1735E-01	-2.4768E-06	1.9819E-06	1.4624E-06
100	1.0000E+02	8.7569E+02	1.3784E+01	-5.4012E+00	8.9691E+00	7.7093E+00	-2.9383E-04	1.9751E-04	1.5130E-04
200	2.0000E+02	8.5139E+02	1.5526E+01	-6.4797E+00	9.3174E+00	8.7599E+00	-6.6740E-04	3.9274E-04	3.2909E-04
300	3.0000E+02	8.2708E+02	1.6094E+01	-6.6193E+00	9.5672E+00	9.3799E+00	-1.0447E-03	5.8437E-04	5.1613E-04
400	4.0000E+02	8.0278E+02	1.8817E+01	-7.7147E+00	1.1312E+01	1.0885E+01	-1.4050E-03	7.7340E-04	6.9497E-04
500	5.0000E+02	7.7847E+02	2.5574E+01	-1.0616E+01	1.5498E+01	1.4378E+01	-1.7355E-03	9.6065E-04	8.5648E-04
600	6.0000E+02	7.5417E+02	3.3371E+01	-1.4007E+01	2.0249E+01	1.8402E+01	-2.0554E-03	1.1457E-03	1.0113E-03
700	7.0000E+02	7.2986E+02	4.4683E+01	-1.8772E+01	2.7420E+01	2.4228E+01	-2.3501E-03	1.3280E-03	1.1539E-03
800	8.0000E+02	7.0556E+02	5.8492E+01	-2.4544E+01	3.6285E+01	3.1287E+01	-2.6271E-03	1.5078E-03	1.2875E-03
900	9.0000E+02	6.8125E+02	7.4450E+01	-3.1146E+01	4.6662E+01	3.9413E+01	-2.8893E-03	1.6849E-03	1.4138E-03
1000	1.0000E+03	6.5694E+02	9.2429E+01	-3.8476E+01	5.8524E+01	4.8574E+01	-3.1377E-03	1.8592E-03	1.5338E-03
1100	1.1000E+03	6.3264E+02	1.1142E+02	-4.6136E+01	7.1167E+01	5.8284E+01	-3.3765E-03	2.0303E-03	1.6494E-03
1200	1.2000E+03	6.0833E+02	1.3111E+02	-5.3961E+01	8.4397E+01	6.8431E+01	-3.6078E-03	2.1984E-03	1.7618E-03
1300	1.3000E+03	5.8403E+02	1.5390E+02	-6.2520E+01	1.0031E+02	8.0542E+01	-3.8178E-03	2.3629E-03	1.8686E-03
1400	1.4000E+03	5.5972E+02	1.7931E+02	-7.1607E+01	1.1857E+02	9.4382E+01	-4.0091E-03	2.5236E-03	1.9708E-03
1500	1.5000E+03	5.3542E+02	2.0496E+02	-8.0755E+01	1.3705E+02	1.0833E+02	-4.1956E-03	2.6811E-03	2.0701E-03
1600	1.6000E+03	5.1111E+02	2.3070E+02	-8.9933E+01	1.5562E+02	1.2228E+02	-4.3779E-03	2.8354E-03	2.1667E-03
1700	1.7000E+03	4.8681E+02	2.5644E+02	-9.9113E+01	1.7421E+02	1.3620E+02	-4.5561E-03	2.9865E-03	2.2607E-03
1800	1.8000E+03	4.6250E+02	2.8208E+02	-1.0825E+02	1.9275E+02	1.5002E+02	-4.7297E-03	3.1341E-03	2.3520E-03
1900	1.9000E+03	4.3819E+02	3.0733E+02	-1.1725E+02	2.1102E+02	1.6364E+02	-4.8985E-03	3.2776E-03	2.4406E-03
2000	2.0000E+03	4.1389E+02	3.3258E+02	-1.2625E+02	2.2931E+02	1.7720E+02	-5.0631E-03	3.4179E-03	2.5266E-03
2100	2.1000E+03	3.8958E+02	3.5734E+02	-1.3507E+02	2.4726E+02	1.9050E+02	-5.2226E-03	3.5539E-03	2.6099E-03
2200	2.2000E+03	3.6528E+02	3.8203E+02	-1.4387E+02	2.6516E+02	2.0371E+02	-5.3779E-03	3.6866E-03	2.6905E-03
2300	2.3000E+03	3.4097E+02	4.0582E+02	-1.5233E+02	2.8242E+02	2.1649E+02	-5.5286E-03	3.8151E-03	2.7691E-03
2400	2.4000E+03	3.1667E+02	4.2941E+02	-1.6073E+02	2.9955E+02	2.2913E+02	-5.6751E-03	3.9403E-03	2.8453E-03
2500	2.5000E+03	2.9236E+02	4.5202E+02	-1.6876E+02	3.1596E+02	2.4125E+02	-5.8155E-03	4.0601E-03	2.9185E-03
2600	2.6000E+03	2.6806E+02	4.7428E+02	-1.7667E+02	3.3212E+02	2.5317E+02	-5.9515E-03	4.1763E-03	2.9891E-03
2700	2.7000E+03	2.4375E+02	4.9463E+02	-1.8387E+02	3.4690E+02	2.6419E+02	-6.0812E-03	4.2863E-03	3.0576E-03
2800	2.8000E+03	2.1944E+02	5.1374E+02	-1.9061E+02	3.6077E+02	2.7459E+02	-6.2055E-03	4.3913E-03	3.1237E-03
2900	2.9000E+03	1.9514E+02	5.3223E+02	-1.9713E+02	3.7419E+02	2.8464E+02	-6.3244E-03	4.4918E-03	3.1869E-03
3000	3.0000E+03	1.7083E+02	5.5002E+02	-2.0341E+02	3.8710E+02	2.9431E+02	-6.4374E-03	4.5873E-03	3.2468E-03
3100	3.1000E+03	1.4653E+02	5.6727E+02	-2.0951E+02	3.9962E+02	3.0368E+02	-6.5457E-03	4.6790E-03	3.3043E-03
3200	3.2000E+03	1.2222E+02	5.8398E+02	-2.1541E+02	4.1175E+02	3.1274E+02	-6.6493E-03	4.7668E-03	3.3591E-03
3300	3.3000E+03	9.7917E+01	6.0014E+02	-2.2112E+02	4.2348E+02	3.2149E+02	-6.7483E-03	4.8506E-03	3.4115E-03
3400	3.4000E+03	7.3611E+01	6.1549E+02	-2.2654E+02	4.3461E+02	3.2982E+02	-6.8408E-03	4.9289E-03	3.4605E-03
3500	3.5000E+03	4.9306E+01	6.3019E+02	-2.3174E+02	4.4528E+02	3.3779E+02	-6.9281E-03	5.0029E-03	3.5067E-03
3600	3.6000E+03	2.5000E+01	6.4429E+02	-2.3673E+02	4.5551E+02	3.4543E+02	-7.0106E-03	5.0728E-03	3.5503E-03

Cross-Sectional Results at Step 3600
time = 3600.0000

Radius	Seff	Srad	Stan	Sz	Er	Etan	Ez
.000	4.7846E+02	-2.3673E+02	-2.3673E+02	-7.1521E+02	3.1896E-06	3.1896E-06	-1.5193E-03
.099	4.7846E+02	-2.3673E+02	-2.3673E+02	-7.1521E+02	3.1896E-06	3.1896E-06	-1.5193E-03
.197	4.7846E+02	-2.3673E+02	-2.3673E+02	-7.1521E+02	3.1896E-06	3.1896E-06	-1.5193E-03
.296	4.7846E+02	-2.3673E+02	-2.3673E+02	-7.1521E+02	3.1896E-06	3.1896E-06	-1.5193E-03
.394	4.7846E+02	-2.3673E+02	-2.3673E+02	-7.1521E+02	3.1896E-06	3.1896E-06	-1.5193E-03
.493	4.7846E+02	-2.3673E+02	-2.3673E+02	-7.1521E+02	3.1896E-06	3.1896E-06	-1.5193E-03
.592	4.7846E+02	-2.3673E+02	-2.3673E+02	-7.1521E+02	3.1896E-06	3.1896E-06	-1.5193E-03
.592	6.4429E+02	-2.3673E+02	4.5551E+02	3.4543E+02	-7.0106E-03	5.0728E-03	3.5503E-03
.613	6.1224E+02	-2.1277E+02	4.3821E+02	3.5150E+02	-6.5581E-03	4.6567E-03	3.5503E-03

.635	5.8342E+02	-1.9099E+02	4.2230E+02	3.5708E+02	-6.1520E-03	4.2834E-03	3.5503E-03
.656	5.5744E+02	-1.7113E+02	4.0762E+02	3.6222E+02	-5.7864E-03	3.9472E-03	3.5503E-03
.678	5.3399E+02	-1.5299E+02	3.9402E+02	3.6695E+02	-5.4561E-03	3.6434E-03	3.5503E-03
.699	5.1278E+02	-1.3637E+02	3.8138E+02	3.7129E+02	-5.1570E-03	3.3681E-03	3.5503E-03
.721	4.9356E+02	-1.2110E+02	3.6959E+02	3.7527E+02	-4.8852E-03	3.1176E-03	3.5503E-03
.742	4.7612E+02	-1.0704E+02	3.5858E+02	3.7892E+02	-4.6377E-03	2.8893E-03	3.5503E-03
.764	4.6028E+02	-9.4082E+01	3.4827E+02	3.8224E+02	-4.4118E-03	2.6804E-03	3.5503E-03
.785	4.4588E+02	-8.2103E+01	3.3860E+02	3.8528E+02	-4.2051E-03	2.4890E-03	3.5503E-03
.807	4.3277E+02	-7.1012E+01	3.2951E+02	3.8804E+02	-4.0155E-03	2.3130E-03	3.5503E-03
.828	4.2082E+02	-6.0727E+01	3.2096E+02	3.9055E+02	-3.8412E-03	2.1509E-03	3.5503E-03
.850	4.0993E+02	-5.1171E+01	3.1291E+02	3.9283E+02	-3.6808E-03	2.0013E-03	3.5503E-03
.871	3.9999E+02	-4.2281E+01	3.0532E+02	3.9490E+02	-3.5327E-03	1.8628E-03	3.5503E-03
.893	3.9090E+02	-3.3996E+01	2.9816E+02	3.9677E+02	-3.3958E-03	1.7345E-03	3.5503E-03
.914	3.8260E+02	-2.6264E+01	2.9140E+02	3.9846E+02	-3.2690E-03	1.6153E-03	3.5503E-03
.936	3.7501E+02	-1.9039E+01	2.8501E+02	4.0000E+02	-3.1513E-03	1.5043E-03	3.5503E-03
.957	3.6805E+02	-1.2278E+01	2.7897E+02	4.0138E+02	-3.0419E-03	1.4010E-03	3.5503E-03
.979	3.6167E+02	-5.9431E+00	2.7326E+02	4.0263E+02	-2.9401E-03	1.3044E-03	3.5503E-03
1.000	3.5583E+02	.0000E+00	2.6785E+02	4.0375E+02	-2.8451E-03	1.2142E-03	3.5503E-03

```
*************************************
*                                   *
*   F I D E P 2 - VERSION 6         *
*                                   *
*************************************
```

********** PROBLEM TITLE **********

SCS-6/TIMETAL21S(DBP) Concentric Cylinder cooled from 900C to 23C

--------- Average Stress Output ----------

STE	TIME	TEMPERATURE	SZAPP	SZF	SZM	SZ90	EME-F	EME-M	EME-90	EZC
1	1.0000E+00	8.9976E+02	.0000E+00	-2.1792E-01	1.1734E-01	.0000E+00	-5.1037E-07	1.4624E-06	.0000E+00	-1.6216E-06
100	1.0000E+02	8.7569E+02	.0000E+00	-1.8742E+01	1.0092E+01	.0000E+00	-4.4454E-05	1.5130E-04	.0000E+00	-1.5557E-04
200	2.0000E+02	8.5139E+02	.0000E+00	-2.4900E+01	1.3408E+01	.0000E+00	-5.9882E-05	3.2909E-04	.0000E+00	-2.8157E-04
300	3.0000E+02	8.2708E+02	.0000E+00	-2.6413E+01	1.4223E+01	.0000E+00	-6.3719E-05	5.1613E-04	.0000E+00	-3.9522E-04
400	4.0000E+02	8.0278E+02	.0000E+00	-3.0520E+01	1.6434E+01	.0000E+00	-7.3359E-05	6.9497E-04	.0000E+00	-5.1399E-04
500	5.0000E+02	7.7847E+02	.0000E+00	-4.0981E+01	2.2067E+01	.0000E+00	-9.7912E-05	8.5648E-04	.0000E+00	-6.4699E-04
600	6.0000E+02	7.5417E+02	.0000E+00	-5.3285E+01	2.8692E+01	.0000E+00	-1.2671E-04	1.0113E-03	.0000E+00	-7.8346E-04
700	7.0000E+02	7.2986E+02	.0000E+00	-6.9793E+01	3.7581E+01	.0000E+00	-1.6489E-04	1.1539E-03	.0000E+00	-9.2831E-04
800	8.0000E+02	7.0556E+02	.0000E+00	-8.9282E+01	4.8075E+01	.0000E+00	-2.0958E-04	1.2875E-03	.0000E+00	-1.0789E-03
900	9.0000E+02	6.8125E+02	.0000E+00	-1.1106E+02	5.9802E+01	.0000E+00	-2.5909E-04	1.4138E-03	.0000E+00	-1.2335E-03
1000	1.0000E+03	6.5694E+02	.0000E+00	-1.3469E+02	7.2524E+01	.0000E+00	-3.1233E-04	1.5338E-03	.0000E+00	-1.3910E-03
1100	1.1000E+03	6.3264E+02	.0000E+00	-1.5906E+02	8.5648E+01	.0000E+00	-3.6697E-04	1.6494E-03	.0000E+00	-1.5488E-03
1200	1.2000E+03	6.0833E+02	.0000E+00	-1.8371E+02	9.8920E+01	.0000E+00	-4.2192E-04	1.7618E-03	.0000E+00	-1.7060E-03
1300	1.3000E+03	5.8403E+02	.0000E+00	-2.0973E+02	1.1293E+02	.0000E+00	-4.7933E-04	1.8686E-03	.0000E+00	-1.8648E-03
1400	1.4000E+03	5.5972E+02	.0000E+00	-2.3666E+02	1.2743E+02	.0000E+00	-5.3817E-04	1.9708E-03	.0000E+00	-2.0242E-03
1500	1.5000E+03	5.3542E+02	.0000E+00	-2.6361E+02	1.4195E+02	.0000E+00	-5.9675E-04	2.0701E-03	.0000E+00	-2.1824E-03
1600	1.6000E+03	5.1111E+02	.0000E+00	-2.9053E+02	1.5644E+02	.0000E+00	-6.5491E-04	2.1667E-03	.0000E+00	-2.3390E-03
1700	1.7000E+03	4.8681E+02	.0000E+00	-3.1735E+02	1.7088E+02	.0000E+00	-7.1252E-04	2.2607E-03	.0000E+00	-2.4941E-03
1800	1.8000E+03	4.6250E+02	.0000E+00	-3.4394E+02	1.8520E+02	.0000E+00	-7.6934E-04	2.3520E-03	.0000E+00	-2.6476E-03
1900	1.9000E+03	4.3819E+02	.0000E+00	-3.7006E+02	1.9926E+02	.0000E+00	-8.2480E-04	2.4406E-03	.0000E+00	-2.7987E-03
2000	2.0000E+03	4.1389E+02	.0000E+00	-3.9608E+02	2.1327E+02	.0000E+00	-8.7977E-04	2.5266E-03	.0000E+00	-2.9485E-03
2100	2.1000E+03	3.8958E+02	.0000E+00	-4.2154E+02	2.2698E+02	.0000E+00	-9.3323E-04	2.6099E-03	.0000E+00	-3.0959E-03
2200	2.2000E+03	3.6528E+02	.0000E+00	-4.4685E+02	2.4061E+02	.0000E+00	-9.8608E-04	2.6905E-03	.0000E+00	-3.2417E-03
2300	2.3000E+03	3.4097E+02	.0000E+00	-4.7121E+02	2.5373E+02	.0000E+00	-1.0366E-03	2.7691E-03	.0000E+00	-3.3844E-03
2400	2.4000E+03	3.1667E+02	.0000E+00	-4.9532E+02	2.6671E+02	.0000E+00	-1.0864E-03	2.8453E-03	.0000E+00	-3.5253E-03
2500	2.5000E+03	2.9236E+02	.0000E+00	-5.1840E+02	2.7914E+02	.0000E+00	-1.1337E-03	2.9185E-03	.0000E+00	-3.6634E-03
2600	2.6000E+03	2.6806E+02	.0000E+00	-5.4109E+02	2.9136E+02	.0000E+00	-1.1799E-03	2.9891E-03	.0000E+00	-3.7996E-03
2700	2.7000E+03	2.4375E+02	.0000E+00	-5.6191E+02	3.0257E+02	.0000E+00	-1.2220E-03	3.0576E-03	.0000E+00	-3.9308E-03
2800	2.8000E+03	2.1944E+02	.0000E+00	-5.8149E+02	3.1311E+02	.0000E+00	-1.2613E-03	3.1237E-03	.0000E+00	-4.0583E-03
2900	2.9000E+03	1.9514E+02	.0000E+00	-6.0043E+02	3.2331E+02	.0000E+00	-1.2990E-03	3.1869E-03	.0000E+00	-4.1841E-03
3000	3.0000E+03	1.7083E+02	.0000E+00	-6.1866E+02	3.3312E+02	.0000E+00	-1.3351E-03	3.2468E-03	.0000E+00	-4.3084E-03
3100	3.1000E+03	1.4653E+02	.0000E+00	-6.3632E+02	3.4263E+02	.0000E+00	-1.3697E-03	3.3043E-03	.0000E+00	-4.4306E-03
3200	3.2000E+03	1.2222E+02	.0000E+00	-6.5342E+02	3.5184E+02	.0000E+00	-1.4030E-03	3.3591E-03	.0000E+00	-4.5508E-03
3300	3.3000E+03	9.7917E+01	.0000E+00	-6.6994E+02	3.6074E+02	.0000E+00	-1.4349E-03	3.4115E-03	.0000E+00	-4.6688E-03
3400	3.4000E+03	7.3611E+01	.0000E+00	-6.8567E+02	3.6921E+02	.0000E+00	-1.4646E-03	3.4605E-03	.0000E+00	-4.7854E-03
3500	3.5000E+03	4.9306E+01	.0000E+00	-7.0074E+02	3.7732E+02	.0000E+00	-1.4927E-03	3.5067E-03	.0000E+00	-4.9002E-03
3600	3.6000E+03	2.5000E+01	.0000E+00	-7.1521E+02	3.8511E+02	.0000E+00	-1.5193E-03	3.5503E-03	.0000E+00	-5.0130E-03

```
     ************************************
     *                                  *
     *   F I D E P 2 - VERSION 6        *
     *                                  *
     ************************************

************ PROBLEM TITLE ************

SCS-6/TIMETAL21S(DBP) In-Phase TMF - strain control

  ************ GEOMETRY TYPE ************

     Concentric Cylinder Model

  ************ LOADING TYPE ************

      Strain Control

  ********* LOADING HISTORY ************

  POINTS IN HISTORY  13

      Step          Time      Temperature  Axial Strain
     .0000E+00  -3.6000E+03   9.0000E+02    .0000E+00
    1.0000E+03    .0000E+00   2.5000E+01    .0000E+00
    1.1000E+03   1.8000E+02   1.5000E+02  -5.0000E-03
    1.2000E+03   3.6000E+02   6.5000E+02   5.0000E-03
    1.3000E+03   5.4000E+02   1.5000E+02  -5.0000E-03
    1.4000E+03   7.2000E+02   6.5000E+02   5.0000E-03
    1.5000E+03   9.0000E+02   1.5000E+02  -5.0000E-03
    1.6000E+03   1.0800E+03   6.5000E+02   5.0000E-03
    1.7000E+03   1.2600E+03   1.5000E+02  -5.0000E-03
    1.8000E+03   1.4400E+03   6.5000E+02   5.0000E-03
    1.9000E+03   1.6200E+03   1.5000E+02  -5.0000E-03
    2.0000E+03   1.8000E+03   6.5000E+02   5.0000E-03
    2.1000E+03   1.9800E+03   1.5000E+02  -5.0000E-03

********* GEOMETRY INFORMATION  ***********

Number of Cells  2

       For Cell Number : 1

Material Number :  1
            Volume Fraction :  .35
            Nodes in cell   :  5

       For Cell Number : 2

            Material Number :  4
            Volume Fraction :  .65
            Nodes in cell   :  15

  ********** OUTPUT INFORMATION  ************

  Output at Interface for Material:  2

  ********** MATERIAL INFORMATION  ************

  Material for Cell Number :  1

   Thermo-Elastic Response for SCS-6 fiber

  Constitutive model: Elastic
```

---------- MATERIAL PROPERTIES ----------

T(C)	E(GPa)	NU	CTE(1E-6/C)
2.1110E+01	3.9300E+02	2.5000E-01	3.9907E+00
9.3330E+01	3.9000E+02	2.5000E-01	4.0289E+00
2.0444E+02	3.8600E+02	2.5000E-01	4.0989E+00
3.1556E+02	3.8200E+02	2.5000E-01	4.1801E+00
4.2667E+02	3.7800E+02	2.5000E-01	4.2655E+00
5.3778E+02	3.7400E+02	2.5000E-01	4.3510E+00
6.4889E+02	3.7000E+02	2.5000E-01	4.4324E+00
7.6000E+02	3.6500E+02	2.5000E-01	4.5074E+00
8.7111E+02	3.6100E+02	2.5000E-01	4.5718E+00
1.0933E+03	3.5400E+02	2.5000E-01	4.5723E+00

Reference Temperature = 900.0

Material for Cell Number : 2

Bodner-Partom Theory with Directional Hardening for TimetalÒ21S

Constitutive model: Bodner-Partom with Directional Hardening

---------- MATERIAL PROPERTIES ----------

T(C)	E(GPa)	NU	CTE(1E-6/C)
2.3000E+01	1.1200E+02	3.4000E-01	9.7787E+00
2.6000E+02	1.0800E+02	3.4000E-01	1.0713E+01
3.1500E+02	1.0610E+02	3.4000E-01	1.0915E+01
3.6500E+02	1.0410E+02	3.4000E-01	1.1093E+01
4.1500E+02	1.0170E+02	3.4000E-01	1.1267E+01
4.6500E+02	9.9090E+01	3.4000E-01	1.1436E+01
4.8200E+02	9.8110E+01	3.4000E-01	1.1492E+01
5.0000E+02	9.7050E+01	3.4000E-01	1.1550E+01
5.2500E+02	9.5500E+01	3.4000E-01	1.1631E+01
5.5000E+02	9.3870E+01	3.4000E-01	1.1710E+01
5.7500E+02	9.2170E+01	3.4000E-01	1.1788E+01
6.0000E+02	9.0400E+01	3.4000E-01	1.1865E+01
6.5000E+02	8.6610E+01	3.4000E-01	1.2014E+01
7.6000E+02	7.7220E+01	3.4000E-01	1.2323E+01
8.1500E+02	7.1960E+01	3.4000E-01	1.2467E+01
9.0000E+02	6.3120E+01	3.4000E-01	1.2689E+01

Reference Temperature = 900.0

T(C)	N	Z0=Z2(1/S)	Z3(MPa)	M2(1/MPa)	
2.3000E+01	4.8000E+00	1.5500E+03	1.0000E+02	3.5000E-01	
2.6000E+02	3.5000E+00	1.3000E+03	3.0000E+02	3.5000E-01	
3.1500E+02	3.0540E+00	1.2504E+03	3.9000E+02	1.5020E+00	
3.6500E+02	2.6490E+00	1.2054E+03	5.0000E+02	2.5490E+00	
4.1500E+02	2.2430E+00	1.1604E+03	6.6000E+02	3.5970E+00	
4.6500E+02	1.8380E+00	1.1153E+03	9.6000E+02	4.6440E+00	
4.8200E+02	1.7000E+00	1.1000E+03	1.1000E+03	5.0000E+00	
5.0000E+02	1.5000E+00	1.0893E+03	1.3000E+03	5.7630E+00	
5.2500E+02	1.2800E+00	1.0744E+03	1.6700E+03	6.8220E+00	
5.5000E+02	1.1000E+00	1.0595E+03	2.1000E+03	7.8810E+00	
5.7500E+02	9.7000E-01	1.0446E+03	2.6000E+03	8.9410E+00	
6.0000E+02	8.2000E-01	1.0298E+03	3.7000E+03	1.0000E+01	
6.5000E+02	7.4000E-01	1.0000E+03	3.8000E+03	1.0000E+01	
7.6000E+02	5.8000E-01	6.0000E+02	4.0000E+03	1.5000E+01	
8.1500E+02	5.5000E-01	3.0000E+02	4.1000E+03	3.0000E+01	
9.0000E+02	5.5000E-01	3.0000E+02	4.3000E+03	3.0000E+01	

```
 ----------------------------------------

   A1=A2      M1          Z1          R1=R2       DO
-9999.0 .0 1600.0 3.0 10000.0
 ----------------------------------------

-------------------- OUTPUT --------------------
```

STEP	TIME	TEMPERATRE	Seff	Srad	Stan	Sz	Erad	Etan	Ez
1	-3.5964E+03	8.9913E+02	7.1692E-01	-2.4595E-01	5.1101E-01	4.2275E-01	-8.9135E-06	7.1332E-06	5.2622E-06
10	-3.5640E+03	8.9125E+02	7.2351E+00	-2.4833E+00	5.1594E+00	4.2599E+00	-8.8801E-05	7.1144E-05	5.2320E-05
20	-3.5280E+03	8.8250E+02	1.1759E+01	-4.5688E+00	7.7945E+00	6.4744E+00	-1.9987E-04	1.4231E-04	1.0536E-04
30	-3.4920E+03	8.7375E+02	1.4255E+01	-5.6047E+00	9.2258E+00	7.9933E+00	-3.2153E-04	2.1320E-04	1.6477E-04
40	-3.4560E+03	8.6500E+02	1.5162E+01	-6.2023E+00	9.4262E+00	8.4442E+00	-4.5489E-04	2.8380E-04	2.2702E-04
50	-3.4200E+03	8.5625E+02	1.5414E+01	-6.4495E+00	9.3042E+00	8.5988E+00	-5.9180E-04	3.5399E-04	2.9198E-04
60	-3.3840E+03	8.4750E+02	1.5524E+01	-6.5302E+00	9.2247E+00	8.7514E+00	-7.2896E-04	4.2363E-04	3.5874E-04
70	-3.3480E+03	8.3875E+02	1.5725E+01	-6.5691E+00	9.3114E+00	8.9948E+00	-8.6490E-04	4.9278E-04	4.2616E-04
80	-3.3120E+03	8.3000E+02	1.5937E+01	-6.6131E+00	9.4315E+00	9.2124E+00	-1.0005E-03	5.6153E-04	4.9364E-04
90	-3.2760E+03	8.2125E+02	1.6159E+01	-6.6689E+00	9.5694E+00	9.4080E+00	-1.1356E-03	6.2991E-04	5.6096E-04
100	-3.2400E+03	8.1250E+02	1.6631E+01	-6.8398E+00	9.8773E+00	9.7025E+00	-1.2687E-03	6.9798E-04	6.2716E-04
110	-3.2040E+03	8.0375E+02	1.8558E+01	-7.6243E+00	1.1134E+01	1.0726E+01	-1.3917E-03	7.6587E-04	6.8824E-04
120	-3.1680E+03	7.9500E+02	2.0887E+01	-8.5998E+00	1.2610E+01	1.1947E+01	-1.5118E-03	8.3354E-04	7.4737E-04
130	-3.1320E+03	7.8625E+02	2.3369E+01	-9.6604E+00	1.4152E+01	1.3238E+01	-1.6304E-03	9.0096E-04	8.0537E-04
140	-3.0960E+03	7.7750E+02	2.5948E+01	-1.0776E+01	1.5730E+01	1.4574E+01	-1.7479E-03	9.6811E-04	8.6252E-04
150	-3.0600E+03	7.6875E+02	2.8604E+01	-1.1933E+01	1.7343E+01	1.5946E+01	-1.8645E-03	1.0350E-03	9.1896E-04
160	-3.0240E+03	7.6000E+02	3.1324E+01	-1.3126E+01	1.8984E+01	1.7347E+01	-1.9802E-03	1.1016E-03	9.7477E-04
170	-2.9880E+03	7.5125E+02	3.4749E+01	-1.4585E+01	2.1123E+01	1.9116E+01	-2.0908E-03	1.1677E-03	1.0284E-03
180	-2.9520E+03	7.4250E+02	3.8661E+01	-1.6233E+01	2.3599E+01	2.1137E+01	-2.1980E-03	1.2335E-03	1.0803E-03
190	-2.9160E+03	7.3375E+02	4.2944E+01	-1.8032E+01	2.6324E+01	2.3344E+01	-2.3026E-03	1.2990E-03	1.1310E-03
200	-2.8800E+03	7.2500E+02	4.7547E+01	-1.9961E+01	2.9265E+01	2.5706E+01	-2.4049E-03	1.3642E-03	1.1804E-03
210	-2.8440E+03	7.1625E+02	5.2447E+01	-2.2009E+01	3.2407E+01	2.8214E+01	-2.5052E-03	1.4290E-03	1.2288E-03
220	-2.8080E+03	7.0750E+02	5.7632E+01	-2.4171E+01	3.5747E+01	3.0862E+01	-2.6035E-03	1.4935E-03	1.2762E-03
230	-2.7720E+03	6.9875E+02	6.3095E+01	-2.6441E+01	3.9281E+01	3.3647E+01	-2.6998E-03	1.5576E-03	1.3226E-03
240	-2.7360E+03	6.9000E+02	6.8831E+01	-2.8814E+01	4.3010E+01	3.6569E+01	-2.7943E-03	1.6214E-03	1.3681E-03
250	-2.7000E+03	6.8125E+02	7.4834E+01	-3.1285E+01	4.6933E+01	3.9626E+01	-2.8869E-03	1.6849E-03	1.4127E-03
260	-2.6640E+03	6.7250E+02	8.1098E+01	-3.3850E+01	5.1048E+01	4.2818E+01	-2.9778E-03	1.7480E-03	1.4566E-03
270	-2.6280E+03	6.6375E+02	8.7617E+01	-3.6504E+01	5.5354E+01	4.6142E+01	-3.0669E-03	1.8107E-03	1.4997E-03
280	-2.5920E+03	6.5500E+02	9.4385E+01	-3.9243E+01	5.9848E+01	4.9598E+01	-3.1544E-03	1.8731E-03	1.5420E-03
290	-2.5560E+03	6.4625E+02	1.0130E+02	-4.2029E+01	6.4453E+01	5.3128E+01	-3.2405E-03	1.9349E-03	1.5838E-03
300	-2.5200E+03	6.3750E+02	1.0810E+02	-4.4773E+01	6.8979E+01	5.6606E+01	-3.3263E-03	1.9964E-03	1.6253E-03
310	-2.4840E+03	6.2875E+02	1.1501E+02	-4.7539E+01	7.3601E+01	6.0158E+01	-3.4111E-03	2.0574E-03	1.6664E-03
320	-2.4480E+03	6.2000E+02	1.2205E+02	-5.0342E+01	7.8329E+01	6.3788E+01	-3.4947E-03	2.1181E-03	1.7070E-03
330	-2.4120E+03	6.1125E+02	1.2924E+02	-5.3187E+01	8.3173E+01	6.7499E+01	-3.5773E-03	2.1784E-03	1.7472E-03
340	-2.3760E+03	6.0250E+02	1.3657E+02	-5.6075E+01	8.8139E+01	7.1294E+01	-3.6586E-03	2.2384E-03	1.7869E-03
350	-2.3400E+03	5.9375E+02	1.4469E+02	-5.9138E+01	9.3789E+01	7.5597E+01	-3.7348E-03	2.2977E-03	1.8255E-03
360	-2.3040E+03	5.8500E+02	1.5359E+02	-6.2368E+01	1.0013E+02	8.0410E+01	-3.8060E-03	2.3564E-03	1.8630E-03
370	-2.2680E+03	5.7625E+02	1.6269E+02	-6.5635E+01	1.0666E+02	8.5365E+01	-3.8756E-03	2.4147E-03	1.9002E-03
380	-2.2320E+03	5.6750E+02	1.7185E+02	-6.8903E+01	1.1324E+02	9.0352E+01	-3.9444E-03	2.4725E-03	1.9370E-03
390	-2.1960E+03	5.5875E+02	1.8104E+02	-7.2185E+01	1.1986E+02	9.5363E+01	-4.0126E-03	2.5300E-03	1.9734E-03
400	-2.1600E+03	5.5000E+02	1.9029E+02	-7.5483E+01	1.2652E+02	1.0039E+02	-4.0802E-03	2.5870E-03	2.0094E-03
410	-2.1240E+03	5.4125E+02	1.9951E+02	-7.8771E+01	1.3316E+02	1.0540E+02	-4.1472E-03	2.6436E-03	2.0450E-03
420	-2.0880E+03	5.3250E+02	2.0877E+02	-8.2075E+01	1.3984E+02	1.1043E+02	-4.2137E-03	2.6998E-03	2.0804E-03
430	-2.0520E+03	5.2375E+02	2.1807E+02	-8.5389E+01	1.4655E+02	1.1547E+02	-4.2797E-03	2.7557E-03	2.1154E-03
440	-2.0160E+03	5.1500E+02	2.2731E+02	-8.8684E+01	1.5322E+02	1.2048E+02	-4.3450E-03	2.8110E-03	2.1499E-03
450	-1.9800E+03	5.0625E+02	2.3658E+02	-9.1989E+01	1.5991E+02	1.2550E+02	-4.4097E-03	2.8659E-03	2.1842E-03
460	-1.9440E+03	4.9750E+02	2.4585E+02	-9.5297E+01	1.6661E+02	1.3051E+02	-4.4740E-03	2.9204E-03	2.2181E-03
470	-1.9080E+03	4.8875E+02	2.5512E+02	-9.8599E+01	1.7330E+02	1.3552E+02	-4.5379E-03	2.9746E-03	2.2518E-03
480	-1.8720E+03	4.8000E+02	2.6439E+02	-1.0190E+02	1.8000E+02	1.4053E+02	-4.6011E-03	3.0283E-03	2.2851E-03
490	-1.8360E+03	4.7125E+02	2.7362E+02	-1.0520E+02	1.8668E+02	1.4551E+02	-4.6637E-03	3.0814E-03	2.3180E-03
500	-1.8000E+03	4.6250E+02	2.8282E+02	-1.0848E+02	1.9333E+02	1.5047E+02	-4.7256E-03	3.1341E-03	2.3505E-03
510	-1.7640E+03	4.5375E+02	2.9192E+02	-1.1171E+02	1.9991E+02	1.5538E+02	-4.7868E-03	3.1861E-03	2.3827E-03

520	-1.7280E+03	4.4500E+02	3.0101E+02	-1.1495E+02	2.0649E+02	1.6028E+02	-4.8475E-03	3.2377E-03	2.4146E-03
530	-1.6920E+03	4.3625E+02	3.1011E+02	-1.1819E+02	2.1308E+02	1.6518E+02	-4.9077E-03	3.2889E-03	2.4461E-03
540	-1.6560E+03	4.2750E+02	3.1921E+02	-1.2143E+02	2.1967E+02	1.7007E+02	-4.9673E-03	3.3397E-03	2.4773E-03
550	-1.6200E+03	4.1875E+02	3.2831E+02	-1.2468E+02	2.2626E+02	1.7496E+02	-5.0264E-03	3.3901E-03	2.5081E-03
560	-1.5840E+03	4.1000E+02	3.3731E+02	-1.2788E+02	2.3278E+02	1.7979E+02	-5.0848E-03	3.4398E-03	2.5386E-03
570	-1.5480E+03	4.0125E+02	3.4623E+02	-1.3106E+02	2.3925E+02	1.8459E+02	-5.1424E-03	3.4890E-03	2.5687E-03
580	-1.5120E+03	3.9250E+02	3.5515E+02	-1.3424E+02	2.4571E+02	1.8937E+02	-5.1995E-03	3.5377E-03	2.5985E-03
590	-1.4760E+03	3.8375E+02	3.6405E+02	-1.3741E+02	2.5217E+02	1.9414E+02	-5.2561E-03	3.5860E-03	2.6279E-03
600	-1.4400E+03	3.7500E+02	3.7294E+02	-1.4058E+02	2.5862E+02	1.9890E+02	-5.3121E-03	3.6339E-03	2.6570E-03
610	-1.4040E+03	3.6625E+02	3.8183E+02	-1.4375E+02	2.6506E+02	2.0365E+02	-5.3676E-03	3.6814E-03	2.6858E-03
620	-1.3680E+03	3.5750E+02	3.9045E+02	-1.4682E+02	2.7132E+02	2.0829E+02	-5.4224E-03	3.7281E-03	2.7144E-03
630	-1.3320E+03	3.4875E+02	3.9902E+02	-1.4986E+02	2.7753E+02	2.1289E+02	-5.4767E-03	3.7744E-03	2.7427E-03
640	-1.2960E+03	3.4000E+02	4.0756E+02	-1.5290E+02	2.8373E+02	2.1747E+02	-5.5304E-03	3.8202E-03	2.7707E-03
650	-1.2600E+03	3.3125E+02	4.1607E+02	-1.5593E+02	2.8991E+02	2.2203E+02	-5.5835E-03	3.8656E-03	2.7983E-03
660	-1.2240E+03	3.2250E+02	4.2456E+02	-1.5895E+02	2.9607E+02	2.2658E+02	-5.6361E-03	3.9105E-03	2.8257E-03
670	-1.1880E+03	3.1375E+02	4.3298E+02	-1.6194E+02	3.0219E+02	2.3109E+02	-5.6881E-03	3.9549E-03	2.8526E-03
680	-1.1520E+03	3.0500E+02	4.4112E+02	-1.6484E+02	3.0810E+02	2.3546E+02	-5.7389E-03	3.9983E-03	2.8792E-03
690	-1.1160E+03	2.9625E+02	4.4923E+02	-1.6771E+02	3.1398E+02	2.3981E+02	-5.7892E-03	4.0412E-03	2.9054E-03
700	-1.0800E+03	2.8750E+02	4.5729E+02	-1.7058E+02	3.1984E+02	2.4413E+02	-5.8389E-03	4.0836E-03	2.9312E-03
710	-1.0440E+03	2.7875E+02	4.6532E+02	-1.7343E+02	3.2567E+02	2.4843E+02	-5.8880E-03	4.1256E-03	2.9568E-03
720	-1.0080E+03	2.7000E+02	4.7331E+02	-1.7628E+02	3.3148E+02	2.5271E+02	-5.9366E-03	4.1671E-03	2.9820E-03
730	-9.7200E+02	2.6125E+02	4.8126E+02	-1.7910E+02	3.3725E+02	2.5696E+02	-5.9846E-03	4.2082E-03	3.0069E-03
740	-9.3600E+02	2.5250E+02	4.8844E+02	-1.8164E+02	3.4247E+02	2.6086E+02	-6.0312E-03	4.2476E-03	3.0316E-03
750	-9.0000E+02	2.4375E+02	4.9544E+02	-1.8411E+02	3.4755E+02	2.6467E+02	-6.0770E-03	4.2863E-03	3.0560E-03
760	-8.6400E+02	2.3500E+02	5.0238E+02	-1.8655E+02	3.5258E+02	2.6845E+02	-6.1223E-03	4.3245E-03	3.0801E-03
770	-8.2800E+02	2.2625E+02	5.0925E+02	-1.8897E+02	3.5757E+02	2.7219E+02	-6.1670E-03	4.3623E-03	3.1039E-03
780	-7.9200E+02	2.1750E+02	5.1606E+02	-1.9138E+02	3.6251E+02	2.7589E+02	-6.2110E-03	4.3995E-03	3.1273E-03
790	-7.5600E+02	2.0875E+02	5.2280E+02	-1.9375E+02	3.6740E+02	2.7956E+02	-6.2545E-03	4.4363E-03	3.1504E-03
800	-7.2000E+02	2.0000E+02	5.2942E+02	-1.9609E+02	3.7221E+02	2.8316E+02	-6.2970E-03	4.4722E-03	3.1730E-03
810	-6.8400E+02	1.9125E+02	5.3593E+02	-1.9839E+02	3.7693E+02	2.8670E+02	-6.3386E-03	4.5073E-03	3.1951E-03
820	-6.4800E+02	1.8250E+02	5.4236E+02	-2.0066E+02	3.8160E+02	2.9020E+02	-6.3795E-03	4.5420E-03	3.2168E-03
830	-6.1200E+02	1.7375E+02	5.4873E+02	-2.0290E+02	3.8622E+02	2.9366E+02	-6.4198E-03	4.5761E-03	3.2382E-03
840	-5.7600E+02	1.6500E+02	5.5503E+02	-2.0513E+02	3.9079E+02	2.9708E+02	-6.4596E-03	4.6097E-03	3.2593E-03
850	-5.4000E+02	1.5625E+02	5.6126E+02	-2.0733E+02	3.9531E+02	3.0046E+02	-6.4987E-03	4.6428E-03	3.2800E-03
860	-5.0400E+02	1.4750E+02	5.6741E+02	-2.0950E+02	3.9978E+02	3.0380E+02	-6.5372E-03	4.6754E-03	3.3004E-03
870	-4.6800E+02	1.3875E+02	5.7350E+02	-2.1165E+02	4.0420E+02	3.0710E+02	-6.5751E-03	4.7075E-03	3.3205E-03
880	-4.3200E+02	1.3000E+02	5.7952E+02	-2.1378E+02	4.0857E+02	3.1037E+02	-6.6124E-03	4.7391E-03	3.3403E-03
890	-3.9600E+02	1.2125E+02	5.8546E+02	-2.1588E+02	4.1288E+02	3.1359E+02	-6.6491E-03	4.7702E-03	3.3597E-03
900	-3.6000E+02	1.1250E+02	5.9133E+02	-2.1795E+02	4.1715E+02	3.1677E+02	-6.6852E-03	4.8008E-03	3.3788E-03
910	-3.2400E+02	1.0375E+02	5.9714E+02	-2.2000E+02	4.2136E+02	3.1992E+02	-6.7207E-03	4.8309E-03	3.3976E-03
920	-2.8800E+02	9.5000E+01	6.0287E+02	-2.2203E+02	4.2552E+02	3.2302E+02	-6.7556E-03	4.8604E-03	3.4160E-03
930	-2.5200E+02	8.6250E+01	6.0843E+02	-2.2399E+02	4.2956E+02	3.2604E+02	-6.7892E-03	4.8889E-03	3.4338E-03
940	-2.1600E+02	7.7500E+01	6.1390E+02	-2.2593E+02	4.3353E+02	3.2901E+02	-6.8221E-03	4.9168E-03	3.4512E-03
950	-1.8000E+02	6.8750E+01	6.1930E+02	-2.2783E+02	4.3744E+02	3.3194E+02	-6.8544E-03	4.9441E-03	3.4683E-03
960	-1.4400E+02	6.0000E+01	6.2462E+02	-2.2971E+02	4.4130E+02	3.3482E+02	-6.8860E-03	4.9709E-03	3.4851E-03
970	-1.0800E+02	5.1250E+01	6.2986E+02	-2.3157E+02	4.4510E+02	3.3766E+02	-6.9170E-03	4.9971E-03	3.5015E-03
980	-7.2000E+01	4.2500E+01	6.3503E+02	-2.3339E+02	4.4885E+02	3.4046E+02	-6.9474E-03	5.0229E-03	3.5176E-03
990	-3.6000E+01	3.3750E+01	6.4012E+02	-2.3519E+02	4.5254E+02	3.4322E+02	-6.9772E-03	5.0481E-03	3.5333E-03
1000	.0000E+00	2.5000E+01	6.4513E+02	-2.3697E+02	4.5618E+02	3.4593E+02	-7.0063E-03	5.0728E-03	3.5487E-03

Cross-Sectional Results at Step 1000
time = .0000

Radius	Seff	Srad	Stan	Sz	Er	Etan	Ez
.000	4.7896E+02	-2.3697E+02	-2.3697E+02	-7.1595E+02	3.2106E-06	3.2106E-06	-1.5209E-03
.148	4.7896E+02	-2.3697E+02	-2.3697E+02	-7.1595E+02	3.2106E-06	3.2106E-06	-1.5209E-03
.296	4.7896E+02	-2.3697E+02	-2.3697E+02	-7.1595E+02	3.2106E-06	3.2106E-06	-1.5209E-03
.444	4.7896E+02	-2.3697E+02	-2.3697E+02	-7.1595E+02	3.2106E-06	3.2106E-06	-1.5209E-03
.592	4.7896E+02	-2.3697E+02	-2.3697E+02	-7.1595E+02	3.2106E-06	3.2106E-06	-1.5209E-03
.592	6.4513E+02	-2.3697E+02	4.5618E+02	3.4593E+02	-7.0063E-03	5.0728E-03	3.5487E-03
.621	6.0232E+02	-2.0494E+02	4.3296E+02	3.5403E+02	-6.4036E-03	4.5184E-03	3.5487E-03

.650	5.6523E+02	-1.7678E+02	4.1220E+02	3.6126E+02	-5.8825E-03	4.0391E-03	3.5487E-03	
.679	5.3296E+02	-1.5188E+02	3.9351E+02	3.6772E+02	-5.4293E-03	3.6221E-03	3.5487E-03	
.708	5.0481E+02	-1.2977E+02	3.7660E+02	3.7347E+02	-5.0329E-03	3.2570E-03	3.5487E-03	
.737	4.8017E+02	-1.1004E+02	3.6121E+02	3.7858E+02	-4.6845E-03	2.9356E-03	3.5487E-03	
.767	4.5855E+02	-9.2377E+01	3.4714E+02	3.8309E+02	-4.3769E-03	2.6511E-03	3.5487E-03	
.796	4.3955E+02	-7.6503E+01	3.3424E+02	3.8708E+02	-4.1041E-03	2.3983E-03	3.5487E-03	
.825	4.2281E+02	-6.2189E+01	3.2237E+02	3.9058E+02	-3.8612E-03	2.1724E-03	3.5487E-03	
.854	4.0805E+02	-4.9242E+01	3.1144E+02	3.9365E+02	-3.6442E-03	1.9699E-03	3.5487E-03	
.883	3.9501E+02	-3.7497E+01	3.0135E+02	3.9634E+02	-3.4494E-03	1.7875E-03	3.5487E-03	
.912	3.8346E+02	-2.6814E+01	2.9202E+02	3.9869E+02	-3.2741E-03	1.6228E-03	3.5487E-03	
.942	3.7324E+02	-1.7071E+01	2.8339E+02	4.0074E+02	-3.1157E-03	1.4734E-03	3.5487E-03	
.971	3.6416E+02	-8.1631E+00	2.7539E+02	4.0252E+02	-2.9722E-03	1.3376E-03	3.5487E-03	
1.000	3.5609E+02	.0000E+00	2.6796E+02	4.0406E+02	-2.8418E-03	1.2137E-03	3.5487E-03	
1010	1.8000E+01	3.7500E+01	6.1213E+02	-2.3216E+02	4.4625E+02	2.7888E+02	-6.7377E-03	5.1804E-03	2.9689E-03
1020	3.6000E+01	5.0000E+01	5.8459E+02	-2.2730E+02	4.3622E+02	2.1192E+02	-6.4675E-03	5.2871E-03	2.3878E-03
1030	5.4000E+01	6.2500E+01	5.6326E+02	-2.2239E+02	4.2609E+02	1.4505E+02	-6.1959E-03	5.3928E-03	1.8055E-03
1040	7.2000E+01	7.5000E+01	5.4885E+02	-2.1743E+02	4.1586E+02	7.8273E+01	-5.9228E-03	5.4976E-03	1.2220E-03
1050	9.0000E+01	8.7500E+01	5.4187E+02	-2.1243E+02	4.0553E+02	1.1586E+01	-5.6482E-03	5.6015E-03	6.3724E-04
1060	1.0800E+02	1.0000E+02	5.4251E+02	-2.0734E+02	3.9504E+02	-5.5019E+01	-5.3716E-03	5.7038E-03	5.1252E-05
1070	1.2600E+02	1.1250E+02	5.5072E+02	-2.0219E+02	3.8441E+02	-1.2154E+02	-5.0931E-03	5.8048E-03	-5.3597E-04
1080	1.4400E+02	1.2500E+02	5.6621E+02	-1.9700E+02	3.7368E+02	-1.8796E+02	-4.8131E-03	5.9048E-03	-1.1244E-03
1090	1.6200E+02	1.3750E+02	5.8838E+02	-1.9175E+02	3.6286E+02	-2.5429E+02	-4.5317E-03	6.0039E-03	-1.7141E-03
1100	1.8000E+02	1.5000E+02	6.1647E+02	-1.8647E+02	3.5194E+02	-3.2052E+02	-4.2488E-03	6.1022E-03	-2.3050E-03
1110	1.9800E+02	2.0000E+02	5.5104E+02	-1.7681E+02	3.3214E+02	-2.5305E+02	-4.3227E-03	5.7169E-03	-1.6810E-03
1120	2.1600E+02	2.5000E+02	4.8825E+02	-1.6612E+02	3.1021E+02	-1.8914E+02	-4.3705E-03	5.3139E-03	-1.0767E-03
1130	2.3400E+02	3.0000E+02	4.2554E+02	-1.5329E+02	2.8405E+02	-1.2862E+02	-4.3876E-03	4.8926E-03	-4.9860E-04
1140	2.5200E+02	3.5000E+02	3.6569E+02	-1.3918E+02	2.5535E+02	-7.2270E+01	-4.3780E-03	4.4550E-03	5.7233E-05
1150	2.7000E+02	4.0000E+02	3.1027E+02	-1.2410E+02	2.2477E+02	-2.0250E+01	-4.3448E-03	4.0032E-03	5.9285E-04
1160	2.8800E+02	4.5000E+02	2.6141E+02	-1.0839E+02	1.9295E+02	2.7161E+01	-4.2888E-03	3.5380E-03	1.1088E-03
1170	3.0600E+02	5.0000E+02	2.2154E+02	-9.2210E+01	1.6024E+02	6.9783E+01	-4.2102E-03	3.0591E-03	1.6055E-03
1180	3.2400E+02	5.5000E+02	1.9375E+02	-7.5740E+01	1.2705E+02	1.0749E+02	-4.1106E-03	2.5679E-03	2.0840E-03
1190	3.4200E+02	6.0000E+02	1.7286E+02	-5.6761E+01	8.9685E+01	1.3392E+02	-4.0234E-03	2.0690E-03	2.5450E-03
1200	3.6000E+02	6.5000E+02	1.6096E+02	-3.7320E+01	5.3165E+01	1.4852E+02	-3.9404E-03	1.5587E-03	2.9890E-03
1210	3.7800E+02	6.0000E+02	1.5639E+02	-5.2839E+01	8.4425E+01	1.1742E+02	-4.0931E-03	2.0756E-03	2.5450E-03
1220	3.9600E+02	5.5000E+02	1.7200E+02	-6.9063E+01	1.1716E+02	8.3849E+01	-4.2133E-03	2.5791E-03	2.0840E-03
1230	4.1400E+02	5.0000E+02	2.0424E+02	-8.5319E+01	1.5004E+02	4.5350E+01	-4.3131E-03	3.0706E-03	1.6055E-03
1240	4.3200E+02	4.5000E+02	2.4878E+02	-1.0131E+02	1.8248E+02	2.0216E+00	-4.3920E-03	3.5497E-03	1.1088E-03
1250	4.5000E+02	4.0000E+02	3.0179E+02	-1.1685E+02	2.1405E+02	-4.6027E+01	-4.4482E-03	4.0152E-03	5.9285E-04
1260	4.6800E+02	3.5000E+02	3.6075E+02	-1.3177E+02	2.4441E+02	-9.8618E+01	-4.4815E-03	4.4671E-03	5.7233E-05
1270	4.8600E+02	3.0000E+02	4.2361E+02	-1.4576E+02	2.7292E+02	-1.5545E+02	-4.4912E-03	4.9049E-03	-4.9860E-04
1280	5.0400E+02	2.5000E+02	4.8893E+02	-1.5848E+02	2.9893E+02	-2.1636E+02	-4.4742E-03	5.3263E-03	-1.0767E-03
1290	5.2200E+02	2.0000E+02	5.5403E+02	-1.6911E+02	3.2078E+02	-2.8048E+02	-4.4265E-03	5.7294E-03	-1.6810E-03
1300	5.4000E+02	1.5000E+02	6.2151E+02	-1.7872E+02	3.4050E+02	-3.4816E+02	-4.3526E-03	6.1147E-03	-2.3050E-03
1310	5.5800E+02	2.0000E+02	5.5403E+02	-1.6911E+02	3.2078E+02	-2.8048E+02	-4.4265E-03	5.7294E-03	-1.6810E-03
1320	5.7600E+02	2.5000E+02	4.8893E+02	-1.5848E+02	2.9893E+02	-2.1636E+02	-4.4742E-03	5.3263E-03	-1.0767E-03
1330	5.9400E+02	3.0000E+02	4.2361E+02	-1.4576E+02	2.7292E+02	-1.5545E+02	-4.4912E-03	4.9049E-03	-4.9860E-04
1340	6.1200E+02	3.5000E+02	3.6075E+02	-1.3177E+02	2.4441E+02	-9.8618E+01	-4.4815E-03	4.4671E-03	5.7233E-05
1350	6.3000E+02	4.0000E+02	3.0179E+02	-1.1685E+02	2.1405E+02	-4.6027E+01	-4.4482E-03	4.0152E-03	5.9285E-04
1360	6.4800E+02	4.5000E+02	2.4878E+02	-1.0131E+02	1.8248E+02	2.0216E+00	-4.3920E-03	3.5497E-03	1.1088E-03
1370	6.6600E+02	5.0000E+02	2.0424E+02	-8.5319E+01	1.5004E+02	4.5350E+01	-4.3131E-03	3.0706E-03	1.6055E-03
1380	6.8400E+02	5.5000E+02	1.7200E+02	-6.9063E+01	1.1716E+02	8.3849E+01	-4.2133E-03	2.5791E-03	2.0840E-03
1390	7.0200E+02	6.0000E+02	1.5413E+02	-5.2617E+01	8.2782E+01	1.1512E+02	-4.1066E-03	2.0760E-03	2.5450E-03
1400	7.2000E+02	6.5000E+02	1.4703E+02	-3.4268E+01	4.8200E+01	1.3548E+02	-4.0008E-03	1.5639E-03	2.9890E-03
1410	7.3800E+02	6.0000E+02	1.4438E+02	-4.9964E+01	7.9880E+01	1.0551E+02	-4.1460E-03	2.0804E-03	2.5450E-03
1420	7.5600E+02	5.5000E+02	1.6199E+02	-6.6084E+01	1.1245E+02	7.1494E+01	-4.2663E-03	2.5841E-03	2.0840E-03
1430	7.7400E+02	5.0000E+02	1.9696E+02	-8.2244E+01	1.4519E+02	3.2578E+01	-4.3662E-03	3.0757E-03	1.6055E-03
1440	7.9200E+02	4.5000E+02	2.4406E+02	-9.8154E+01	1.7749E+02	-1.1120E+01	-4.4452E-03	3.5549E-03	1.1088E-03
1450	8.1000E+02	4.0000E+02	2.9920E+02	-1.1362E+02	2.0895E+02	-5.9502E+01	-4.5014E-03	4.0205E-03	5.9285E-04
1460	8.2800E+02	3.5000E+02	3.5990E+02	-1.2847E+02	2.3920E+02	-1.1239E+02	-4.5348E-03	4.4725E-03	5.7233E-05
1470	8.4600E+02	3.0000E+02	4.2421E+02	-1.4240E+02	2.6763E+02	-1.6947E+02	-4.5446E-03	4.9104E-03	-4.9860E-04
1480	8.6400E+02	2.5000E+02	4.9077E+02	-1.5508E+02	2.9356E+02	-2.3058E+02	-4.5276E-03	5.3319E-03	-1.0767E-03

1490	8.8200E+02	2.0000E+02	5.5696E+02	-1.6568E+02	3.1537E+02	-2.9482E+02	-4.4799E-03	5.7349E-03	-1.6810E-03
1500	9.0000E+02	1.5000E+02	6.2539E+02	-1.7526E+02	3.3505E+02	-3.6261E+02	-4.4060E-03	6.1203E-03	-2.3050E-03
1510	9.1800E+02	2.0000E+02	5.5696E+02	-1.6568E+02	3.1537E+02	-2.9482E+02	-4.4799E-03	5.7349E-03	-1.6810E-03
1520	9.3600E+02	2.5000E+02	4.9077E+02	-1.5508E+02	2.9356E+02	-2.3058E+02	-4.5276E-03	5.3319E-03	-1.0767E-03
1530	9.5400E+02	3.0000E+02	4.2421E+02	-1.4240E+02	2.6763E+02	-1.6947E+02	-4.5446E-03	4.9104E-03	-4.9860E-04
1540	9.7200E+02	3.5000E+02	3.5990E+02	-1.2847E+02	2.3920E+02	-1.1239E+02	-4.5348E-03	4.4725E-03	5.7233E-05
1550	9.9000E+02	4.0000E+02	2.9920E+02	-1.1362E+02	2.0895E+02	-5.9502E+01	-4.5014E-03	4.0205E-03	5.9285E-04
1560	1.0080E+03	4.5000E+02	2.4406E+02	-9.8154E+01	1.7749E+02	-1.1120E+01	-4.4452E-03	3.5549E-03	1.1088E-03
1570	1.0260E+03	5.0000E+02	1.9696E+02	-8.2244E+01	1.4519E+02	3.2578E+01	-4.3662E-03	3.0757E-03	1.6055E-03
1580	1.0440E+03	5.5000E+02	1.6199E+02	-6.6084E+01	1.1245E+02	7.1494E+01	-4.2663E-03	2.5841E-03	2.0840E-03
1590	1.0620E+03	6.0000E+02	1.4390E+02	-4.9935E+01	7.9500E+01	1.0501E+02	-4.1490E-03	2.0805E-03	2.5450E-03
1600	1.0800E+03	6.5000E+02	1.3806E+02	-3.2301E+01	4.5155E+01	1.2710E+02	-4.0391E-03	1.5672E-03	2.9890E-03
1610	1.0980E+03	6.0000E+02	1.3621E+02	-4.8004E+01	7.6882E+01	9.7243E+01	-4.1822E-03	2.0837E-03	2.5450E-03
1620	1.1160E+03	5.5000E+02	1.5547E+02	-6.4053E+01	1.0935E+02	6.2906E+01	-4.3026E-03	2.5875E-03	2.0840E-03
1630	1.1340E+03	5.0000E+02	1.9251E+02	-8.0149E+01	1.4199E+02	2.3701E+01	-4.4026E-03	3.0792E-03	1.6055E-03
1640	1.1520E+03	4.5000E+02	2.4142E+02	-9.6001E+01	1.7421E+02	-2.0254E+01	-4.4816E-03	3.5585E-03	1.1088E-03
1650	1.1700E+03	4.0000E+02	2.9801E+02	-1.1141E+02	2.0558E+02	-6.8868E+01	-4.5380E-03	4.0242E-03	5.9285E-04
1660	1.1880E+03	3.5000E+02	3.5988E+02	-1.2622E+02	2.3577E+02	-1.2196E+02	-4.5714E-03	4.4762E-03	5.7233E-05
1670	1.2060E+03	3.0000E+02	4.2515E+02	-1.4010E+02	2.6414E+02	-1.7922E+02	-4.5812E-03	4.9141E-03	-4.9860E-04
1680	1.2240E+03	2.5000E+02	4.9253E+02	-1.5275E+02	2.9002E+02	-2.4047E+02	-4.5643E-03	5.3357E-03	-1.0767E-03
1690	1.2420E+03	2.0000E+02	5.5944E+02	-1.6334E+02	3.1180E+02	-3.0478E+02	-4.5166E-03	5.7387E-03	-1.6810E-03
1700	1.2600E+03	1.5000E+02	6.2851E+02	-1.7290E+02	3.3145E+02	-3.7265E+02	-4.4427E-03	6.1241E-03	-2.3050E-03
1710	1.2780E+03	2.0000E+02	5.5944E+02	-1.6334E+02	3.1180E+02	-3.0478E+02	-4.5166E-03	5.7387E-03	-1.6810E-03
1720	1.2960E+03	2.5000E+02	4.9253E+02	-1.5275E+02	2.9002E+02	-2.4047E+02	-4.5643E-03	5.3357E-03	-1.0767E-03
1730	1.3140E+03	3.0000E+02	4.2515E+02	-1.4010E+02	2.6414E+02	-1.7922E+02	-4.5812E-03	4.9141E-03	-4.9860E-04
1740	1.3320E+03	3.5000E+02	3.5988E+02	-1.2622E+02	2.3577E+02	-1.2196E+02	-4.5714E-03	4.4762E-03	5.7233E-05
1750	1.3500E+03	4.0000E+02	2.9801E+02	-1.1141E+02	2.0558E+02	-6.8868E+01	-4.5380E-03	4.0242E-03	5.9285E-04
1760	1.3680E+03	4.5000E+02	2.4142E+02	-9.6001E+01	1.7421E+02	-2.0254E+01	-4.4816E-03	3.5585E-03	1.1088E-03
1770	1.3860E+03	5.0000E+02	1.9251E+02	-8.0149E+01	1.4199E+02	2.3701E+01	-4.4026E-03	3.0792E-03	1.6055E-03
1780	1.4040E+03	5.5000E+02	1.5547E+02	-6.4053E+01	1.0935E+02	6.2906E+01	-4.3026E-03	2.5875E-03	2.0840E-03
1790	1.4220E+03	6.0000E+02	1.3613E+02	-4.8000E+01	7.6817E+01	9.7161E+01	-4.1827E-03	2.0837E-03	2.5450E-03
1800	1.4400E+03	6.5000E+02	1.3160E+02	-3.0911E+01	4.3077E+01	1.2103E+02	-4.0664E-03	1.5696E-03	2.9890E-03
1810	1.4580E+03	6.0000E+02	1.3029E+02	-4.6588E+01	7.4780E+01	9.1081E+01	-4.2088E-03	2.0861E-03	2.5450E-03
1820	1.4760E+03	5.5000E+02	1.5094E+02	-6.2586E+01	1.0717E+02	5.6510E+01	-4.3293E-03	2.5899E-03	2.0840E-03
1830	1.4940E+03	5.0000E+02	1.8960E+02	-7.8635E+01	1.3974E+02	1.7089E+01	-4.4294E-03	3.0817E-03	1.6055E-03
1840	1.5120E+03	4.5000E+02	2.3986E+02	-9.4445E+01	1.7190E+02	-2.7057E+01	-4.5084E-03	3.5611E-03	1.1088E-03
1850	1.5300E+03	4.0000E+02	2.9751E+02	-1.0982E+02	2.0322E+02	-7.5844E+01	-4.5648E-03	4.0268E-03	5.9285E-04
1860	1.5480E+03	3.5000E+02	3.6022E+02	-1.2459E+02	2.3336E+02	-1.2910E+02	-4.5982E-03	4.4789E-03	5.7233E-05
1870	1.5660E+03	3.0000E+02	4.2619E+02	-1.3845E+02	2.6169E+02	-1.8648E+02	-4.6081E-03	4.9168E-03	-4.9860E-04
1880	1.5840E+03	2.5000E+02	4.9416E+02	-1.5108E+02	2.8754E+02	-2.4784E+02	-4.5912E-03	5.3384E-03	-1.0767E-03
1890	1.6020E+03	2.0000E+02	5.6158E+02	-1.6165E+02	3.0930E+02	-3.1221E+02	-4.5435E-03	5.7414E-03	-1.6810E-03
1900	1.6200E+03	1.5000E+02	6.3110E+02	-1.7120E+02	3.2893E+02	-3.8013E+02	-4.4696E-03	6.1268E-03	-2.3050E-03
1910	1.6380E+03	2.0000E+02	5.6158E+02	-1.6165E+02	3.0930E+02	-3.1221E+02	-4.5435E-03	5.7414E-03	-1.6810E-03
1920	1.6560E+03	2.5000E+02	4.9416E+02	-1.5108E+02	2.8754E+02	-2.4784E+02	-4.5912E-03	5.3384E-03	-1.0767E-03
1930	1.6740E+03	3.0000E+02	4.2619E+02	-1.3845E+02	2.6169E+02	-1.8648E+02	-4.6081E-03	4.9168E-03	-4.9860E-04
1940	1.6920E+03	3.5000E+02	3.6022E+02	-1.2459E+02	2.3336E+02	-1.2910E+02	-4.5982E-03	4.4789E-03	5.7233E-05
1950	1.7100E+03	4.0000E+02	2.9751E+02	-1.0982E+02	2.0322E+02	-7.5844E+01	-4.5648E-03	4.0268E-03	5.9285E-04
1960	1.7280E+03	4.5000E+02	2.3986E+02	-9.4445E+01	1.7190E+02	-2.7057E+01	-4.5084E-03	3.5611E-03	1.1088E-03
1970	1.7460E+03	5.0000E+02	1.8960E+02	-7.8635E+01	1.3974E+02	1.7089E+01	-4.4294E-03	3.0817E-03	1.6055E-03
1980	1.7640E+03	5.5000E+02	1.5094E+02	-6.2586E+01	1.0717E+02	5.6510E+01	-4.3293E-03	2.5899E-03	2.0840E-03
1990	1.7820E+03	6.0000E+02	1.3027E+02	-4.6588E+01	7.4765E+01	9.1063E+01	-4.2090E-03	2.0861E-03	2.5450E-03
2000	1.8000E+03	6.5000E+02	1.2667E+02	-2.9871E+01	4.1575E+01	1.1638E+02	-4.0870E-03	1.5713E-03	2.9890E-03
2010	1.8180E+03	6.0000E+02	1.2581E+02	-4.5523E+01	7.3243E+01	8.6315E+01	-4.2292E-03	2.0879E-03	2.5450E-03
2020	1.8360E+03	5.5000E+02	1.4766E+02	-6.1482E+01	1.0558E+02	5.1562E+01	-4.3496E-03	2.5918E-03	2.0840E-03
2030	1.8540E+03	5.0000E+02	1.8761E+02	-7.7495E+01	1.3810E+02	1.1974E+01	-4.4498E-03	3.0836E-03	1.6055E-03
2040	1.8720E+03	4.5000E+02	2.3892E+02	-9.3274E+01	1.7022E+02	-3.2321E+01	-4.5289E-03	3.5630E-03	1.1088E-03
2050	1.8900E+03	4.0000E+02	2.9738E+02	-1.0862E+02	2.0150E+02	-8.1241E+01	-4.5853E-03	4.0288E-03	5.9285E-04
2060	1.9080E+03	3.5000E+02	3.6072E+02	-1.2337E+02	2.3160E+02	-1.3461E+02	-4.6188E-03	4.4809E-03	5.7233E-05
2070	1.9260E+03	3.0000E+02	4.2720E+02	-1.3720E+02	2.5990E+02	-1.9210E+02	-4.6286E-03	4.9189E-03	-4.9860E-04
2080	1.9440E+03	2.5000E+02	4.9561E+02	-1.4981E+02	2.8573E+02	-2.5354E+02	-4.6117E-03	5.3404E-03	-1.0767E-03
2090	1.9620E+03	2.0000E+02	5.6341E+02	-1.6038E+02	3.0748E+02	-3.1795E+02	-4.5640E-03	5.7435E-03	-1.6810E-03

2100 1.9800E+03 1.5000E+02 6.3327E+02 -1.6992E+02 3.2709E+02 -3.8592E+02 -4.4901E-03 6.1289E-03 -2.3050E-03

Cross-Sectional Results at Step 2100
time = 1980.0000

Radius	Seff	Srad	Stan	Sz	Er	Etan	Ez
.000	2.6175E+03	-1.6992E+02	-1.6992E+02	-2.7875E+03	1.4678E-03	1.4678E-03	-6.9661E-03
.148	2.6175E+03	-1.6992E+02	-1.6992E+02	-2.7875E+03	1.4678E-03	1.4678E-03	-6.9661E-03
.296	2.6175E+03	-1.6992E+02	-1.6992E+02	-2.7875E+03	1.4678E-03	1.4678E-03	-6.9661E-03
.444	2.6175E+03	-1.6992E+02	-1.6992E+02	-2.7875E+03	1.4678E-03	1.4678E-03	-6.9661E-03
.592	2.6175E+03	-1.6992E+02	-1.6992E+02	-2.7875E+03	1.4678E-03	1.4678E-03	-6.9661E-03
.592	6.3327E+02	-1.6992E+02	3.2709E+02	-3.8592E+02	-4.4901E-03	6.1289E-03	-2.3050E-03
.621	6.0895E+02	-1.4695E+02	3.1048E+02	-3.8073E+02	-3.9689E-03	5.6413E-03	-2.3050E-03
.650	5.8810E+02	-1.2675E+02	2.9560E+02	-3.7609E+02	-3.5180E-03	5.2194E-03	-2.3050E-03
.679	5.7014E+02	-1.0890E+02	2.8219E+02	-3.7199E+02	-3.1258E-03	4.8520E-03	-2.3050E-03
.708	5.5458E+02	-9.3043E+01	2.7010E+02	-3.6826E+02	-2.7820E-03	4.5301E-03	-2.3050E-03
.737	5.4112E+02	-7.8898E+01	2.5904E+02	-3.6509E+02	-2.4802E-03	4.2465E-03	-2.3050E-03
.767	5.2940E+02	-6.6231E+01	2.4892E+02	-3.6227E+02	-2.2134E-03	3.9953E-03	-2.3050E-03
.796	5.1918E+02	-5.4849E+01	2.3965E+02	-3.5982E+02	-1.9766E-03	3.7718E-03	-2.3050E-03
.825	5.1027E+02	-4.4586E+01	2.3113E+02	-3.5768E+02	-1.7656E-03	3.5721E-03	-2.3050E-03
.854	5.0250E+02	-3.5304E+01	2.2329E+02	-3.5584E+02	-1.5768E-03	3.3929E-03	-2.3050E-03
.883	4.9569E+02	-2.6883E+01	2.1605E+02	-3.5425E+02	-1.4072E-03	3.2314E-03	-2.3050E-03
.912	4.8972E+02	-1.9224E+01	2.0936E+02	-3.5286E+02	-1.2544E-03	3.0854E-03	-2.3050E-03
.942	4.8440E+02	-1.2239E+01	2.0317E+02	-3.5157E+02	-1.1160E-03	2.9531E-03	-2.3050E-03
.971	4.7966E+02	-5.8524E+00	1.9744E+02	-3.5039E+02	-9.9015E-04	2.8326E-03	-2.3050E-03
1.000	4.7560E+02	.0000E+00	1.9211E+02	-3.4949E+02	-8.7609E-04	2.7227E-03	-2.3050E-03

```
          ************************************
          *                                  *
          *   F I D E P 2 - VERSION 6        *
          *                                  *
          ************************************
```

********** PROBLEM TITLE **********

SCS-6/TIMETAL21S(DBP) In-Phase TMF - strain control

--------- Average Stress Output ----------

STEP	TIME	TEMPERATURE	SZAPP	SZF	SZM	SZ90	EME-F	EME-M	EME-90	EZC
1	-3.5964E+03	8.9913E+02	-3.5580E-05	-7.8499E-01	4.2263E-01	.0000E+00	-1.8383E-06	5.2622E-06	.0000E+00	-5.8387E-06
10	-3.5640E+03	8.9125E+02	-3.5924E-04	-7.9102E+00	4.2588E+00	.0000E+00	-1.8505E-05	5.2320E-05	.0000E+00	-5.8509E-05
20	-3.5280E+03	8.8250E+02	-1.2840E-03	-1.5228E+01	8.1975E+00	.0000E+00	-3.5889E-05	1.0536E-04	.0000E+00	-1.1590E-04
30	-3.4920E+03	8.7375E+02	-1.9511E-03	-1.9586E+01	1.0543E+01	.0000E+00	-4.6503E-05	1.6477E-04	.0000E+00	-1.6651E-04
40	-3.4560E+03	8.6500E+02	-2.5137E-03	-2.2608E+01	1.2170E+01	.0000E+00	-5.4003E-05	2.2702E-04	.0000E+00	-2.1389E-04
50	-3.4200E+03	8.5625E+02	-2.9690E-03	-2.4385E+01	1.3126E+01	.0000E+00	-5.8528E-05	2.9198E-04	.0000E+00	-2.5817E-04
60	-3.3840E+03	8.4750E+02	-3.1772E-03	-2.5315E+01	1.3626E+01	.0000E+00	-6.0935E-05	3.5874E-04	.0000E+00	-3.0024E-04
70	-3.3480E+03	8.3875E+02	-3.2346E-03	-2.5871E+01	1.3926E+01	.0000E+00	-6.2366E-05	4.2616E-04	.0000E+00	-3.4124E-04
80	-3.3120E+03	8.3000E+02	-3.2568E-03	-2.6299E+01	1.4156E+01	.0000E+00	-6.3431E-05	4.9364E-04	.0000E+00	-3.8179E-04
90	-3.2760E+03	8.2125E+02	-3.2743E-03	-2.6681E+01	1.4362E+01	.0000E+00	-6.4352E-05	5.6096E-04	.0000E+00	-4.2211E-04
100	-3.2400E+03	8.1250E+02	-3.3570E-03	-2.7412E+01	1.4755E+01	.0000E+00	-6.6073E-05	6.2716E-04	.0000E+00	-4.6313E-04
110	-3.2040E+03	8.0375E+02	-3.7095E-03	-3.0194E+01	1.6253E+01	.0000E+00	-7.2593E-05	6.8824E-04	.0000E+00	-5.0887E-04
120	-3.1680E+03	7.9500E+02	-4.1631E-03	-3.3675E+01	1.8127E+01	.0000E+00	-8.0760E-05	7.4737E-04	.0000E+00	-5.5617E-04
130	-3.1320E+03	7.8625E+02	-4.6799E-03	-3.7502E+01	2.0186E+01	.0000E+00	-8.9745E-05	8.0537E-04	.0000E+00	-6.0419E-04
140	-3.0960E+03	7.7750E+02	-5.2399E-03	-4.1555E+01	2.2368E+01	.0000E+00	-9.9261E-05	8.6252E-04	.0000E+00	-6.5266E-04
150	-3.0600E+03	7.6875E+02	-5.8320E-03	-4.5781E+01	2.4642E+01	.0000E+00	-1.0918E-04	9.1896E-04	.0000E+00	-7.0144E-04
160	-3.0240E+03	7.6000E+02	-6.4514E-03	-5.0148E+01	2.6993E+01	.0000E+00	-1.1941E-04	9.7477E-04	.0000E+00	-7.5045E-04
170	-2.9880E+03	7.5125E+02	-7.1367E-03	-5.5315E+01	2.9774E+01	.0000E+00	-1.3143E-04	1.0284E-03	.0000E+00	-8.0103E-04
180	-2.9520E+03	7.4250E+02	-7.8747E-03	-6.1058E+01	3.2865E+01	.0000E+00	-1.4473E-04	1.0803E-03	.0000E+00	-8.5279E-04
190	-2.9160E+03	7.3375E+02	-8.6573E-03	-6.7255E+01	3.6201E+01	.0000E+00	-1.5904E-04	1.1310E-03	.0000E+00	-9.0545E-04
200	-2.8800E+03	7.2500E+02	-9.4789E-03	-7.3843E+01	3.9747E+01	.0000E+00	-1.7421E-04	1.1804E-03	.0000E+00	-9.5887E-04
210	-2.8440E+03	7.1625E+02	-1.0333E-02	-8.0781E+01	4.3481E+01	.0000E+00	-1.9014E-04	1.2288E-03	.0000E+00	-1.0129E-03
220	-2.8080E+03	7.0750E+02	-1.1214E-02	-8.8040E+01	4.7389E+01	.0000E+00	-2.0676E-04	1.2762E-03	.0000E+00	-1.0676E-03
230	-2.7720E+03	6.9875E+02	-1.2115E-02	-9.5598E+01	5.1457E+01	.0000E+00	-2.2400E-04	1.3226E-03	.0000E+00	-1.1228E-03
240	-2.7360E+03	6.9000E+02	-1.3031E-02	-1.0343E+02	5.5674E+01	.0000E+00	-2.4182E-04	1.3681E-03	.0000E+00	-1.1784E-03
250	-2.7000E+03	6.8125E+02	-1.3955E-02	-1.1152E+02	6.0030E+01	.0000E+00	-2.6016E-04	1.4127E-03	.0000E+00	-1.2345E-03
260	-2.6640E+03	6.7250E+02	-1.4884E-02	-1.1985E+02	6.4513E+01	.0000E+00	-2.7898E-04	1.4566E-03	.0000E+00	-1.2910E-03
270	-2.6280E+03	6.6375E+02	-1.5811E-02	-1.2840E+02	6.9114E+01	.0000E+00	-2.9824E-04	1.4997E-03	.0000E+00	-1.3478E-03
280	-2.5920E+03	6.5500E+02	-1.6733E-02	-1.3715E+02	7.3824E+01	.0000E+00	-3.1788E-04	1.5420E-03	.0000E+00	-1.4048E-03
290	-2.5560E+03	6.4625E+02	-1.7645E-02	-1.4600E+02	7.8588E+01	.0000E+00	-3.3771E-04	1.5838E-03	.0000E+00	-1.4619E-03
300	-2.5200E+03	6.3750E+02	-1.8563E-02	-1.5474E+02	8.3294E+01	.0000E+00	-3.5732E-04	1.6253E-03	.0000E+00	-1.5186E-03
310	-2.4840E+03	6.2875E+02	-1.9466E-02	-1.6352E+02	8.8018E+01	.0000E+00	-3.7696E-04	1.6664E-03	.0000E+00	-1.5752E-03
320	-2.4480E+03	6.2000E+02	-2.0355E-02	-1.7237E+02	9.2781E+01	.0000E+00	-3.9671E-04	1.7070E-03	.0000E+00	-1.6319E-03
330	-2.4120E+03	6.1125E+02	-2.1231E-02	-1.8130E+02	9.7590E+01	.0000E+00	-4.1660E-04	1.7472E-03	.0000E+00	-1.6885E-03
340	-2.3760E+03	6.0250E+02	-2.2095E-02	-1.9032E+02	1.0245E+02	.0000E+00	-4.3663E-04	1.7869E-03	.0000E+00	-1.7452E-03
350	-2.3400E+03	5.9375E+02	-2.2832E-02	-1.9966E+02	1.0747E+02	.0000E+00	-4.5725E-04	1.8255E-03	.0000E+00	-1.8023E-03
360	-2.3040E+03	5.8500E+02	-2.3445E-02	-2.0930E+02	1.1266E+02	.0000E+00	-4.7841E-04	1.8630E-03	.0000E+00	-1.8599E-03
370	-2.2680E+03	5.7625E+02	-2.4030E-02	-2.1900E+02	1.1788E+02	.0000E+00	-4.9966E-04	1.9002E-03	.0000E+00	-1.9174E-03
380	-2.2320E+03	5.6750E+02	-2.4601E-02	-2.2868E+02	1.2310E+02	.0000E+00	-5.2082E-04	1.9370E-03	.0000E+00	-1.9748E-03
390	-2.1960E+03	5.5875E+02	-2.5171E-02	-2.3838E+02	1.2832E+02	.0000E+00	-5.4198E-04	1.9734E-03	.0000E+00	-2.0320E-03
400	-2.1600E+03	5.5000E+02	-2.5742E-02	-2.4811E+02	1.3356E+02	.0000E+00	-5.6315E-04	2.0094E-03	.0000E+00	-2.0891E-03
410	-2.1240E+03	5.4125E+02	-2.6308E-02	-2.5780E+02	1.3877E+02	.0000E+00	-5.8419E-04	2.0450E-03	.0000E+00	-2.1460E-03
420	-2.0880E+03	5.3250E+02	-2.6876E-02	-2.6751E+02	1.4400E+02	.0000E+00	-6.0524E-04	2.0804E-03	.0000E+00	-2.2027E-03
430	-2.0520E+03	5.2375E+02	-2.7445E-02	-2.7724E+02	1.4924E+02	.0000E+00	-6.2628E-04	2.1154E-03	.0000E+00	-2.2593E-03
440	-2.0160E+03	5.1500E+02	-2.8007E-02	-2.8690E+02	1.5444E+02	.0000E+00	-6.4713E-04	2.1499E-03	.0000E+00	-2.3155E-03
450	-1.9800E+03	5.0625E+02	-2.8571E-02	-2.9657E+02	1.5965E+02	.0000E+00	-6.6796E-04	2.1842E-03	.0000E+00	-2.3716E-03
460	-1.9440E+03	4.9750E+02	-2.9134E-02	-3.0624E+02	1.6485E+02	.0000E+00	-6.8874E-04	2.2181E-03	.0000E+00	-2.4275E-03

470	-1.9080E+03	4.8875E+02	-2.9693E-02	-3.1588E+02	1.7004E+02	.0000E+00	-7.0942E-04	2.2518E-03	.0000E+00	-2.4833E-03
480	-1.8720E+03	4.8000E+02	-3.0252E-02	-3.2550E+02	1.7523E+02	.0000E+00	-7.3004E-04	2.2851E-03	.0000E+00	-2.5388E-03
490	-1.8360E+03	4.7125E+02	-3.0808E-02	-3.3509E+02	1.8038E+02	.0000E+00	-7.5051E-04	2.3180E-03	.0000E+00	-2.5941E-03
500	-1.8000E+03	4.6250E+02	-3.1360E-02	-3.4462E+02	1.8552E+02	.0000E+00	-7.7084E-04	2.3505E-03	.0000E+00	-2.6491E-03
510	-1.7640E+03	4.5375E+02	-3.1900E-02	-3.5403E+02	1.9058E+02	.0000E+00	-7.9087E-04	2.3827E-03	.0000E+00	-2.7036E-03
520	-1.7280E+03	4.4500E+02	-3.2441E-02	-3.6343E+02	1.9565E+02	.0000E+00	-8.1083E-04	2.4146E-03	.0000E+00	-2.7581E-03
530	-1.6920E+03	4.3625E+02	-3.2982E-02	-3.7283E+02	2.0070E+02	.0000E+00	-8.3074E-04	2.4461E-03	.0000E+00	-2.8123E-03
540	-1.6560E+03	4.2750E+02	-3.3523E-02	-3.8221E+02	2.0576E+02	.0000E+00	-8.5059E-04	2.4773E-03	.0000E+00	-2.8663E-03
550	-1.6200E+03	4.1875E+02	-3.4064E-02	-3.9159E+02	2.1080E+02	.0000E+00	-8.7038E-04	2.5081E-03	.0000E+00	-2.9202E-03
560	-1.5840E+03	4.1000E+02	-3.4597E-02	-4.0086E+02	2.1579E+02	.0000E+00	-8.8989E-04	2.5386E-03	.0000E+00	-2.9737E-03
570	-1.5480E+03	4.0125E+02	-3.5123E-02	-4.1003E+02	2.2073E+02	.0000E+00	-9.0918E-04	2.5687E-03	.0000E+00	-3.0269E-03
580	-1.5120E+03	3.9250E+02	-3.5649E-02	-4.1919E+02	2.2566E+02	.0000E+00	-9.2838E-04	2.5985E-03	.0000E+00	-3.0798E-03
590	-1.4760E+03	3.8375E+02	-3.6174E-02	-4.2833E+02	2.3058E+02	.0000E+00	-9.4751E-04	2.6279E-03	.0000E+00	-3.1325E-03
600	-1.4400E+03	3.7500E+02	-3.6699E-02	-4.3745E+02	2.3549E+02	.0000E+00	-9.6656E-04	2.6570E-03	.0000E+00	-3.1851E-03
610	-1.4040E+03	3.6625E+02	-3.7223E-02	-4.4654E+02	2.4039E+02	.0000E+00	-9.8552E-04	2.6858E-03	.0000E+00	-3.2374E-03
620	-1.3680E+03	3.5750E+02	-3.7724E-02	-4.5538E+02	2.4515E+02	.0000E+00	-1.0039E-03	2.7144E-03	.0000E+00	-3.2891E-03
630	-1.3320E+03	3.4875E+02	-3.8220E-02	-4.6415E+02	2.4987E+02	.0000E+00	-1.0221E-03	2.7427E-03	.0000E+00	-3.3404E-03
640	-1.2960E+03	3.4000E+02	-3.8714E-02	-4.7289E+02	2.5457E+02	.0000E+00	-1.0402E-03	2.7707E-03	.0000E+00	-3.3916E-03
650	-1.2600E+03	3.3125E+02	-3.9208E-02	-4.8160E+02	2.5926E+02	.0000E+00	-1.0582E-03	2.7983E-03	.0000E+00	-3.4425E-03
660	-1.2240E+03	3.2250E+02	-3.9700E-02	-4.9027E+02	2.6393E+02	.0000E+00	-1.0761E-03	2.8257E-03	.0000E+00	-3.4932E-03
670	-1.1880E+03	3.1375E+02	-4.0188E-02	-4.9886E+02	2.6856E+02	.0000E+00	-1.0938E-03	2.8526E-03	.0000E+00	-3.5436E-03
680	-1.1520E+03	3.0500E+02	-4.0654E-02	-5.0718E+02	2.7303E+02	.0000E+00	-1.1108E-03	2.8792E-03	.0000E+00	-3.5934E-03
690	-1.1160E+03	2.9625E+02	-4.1118E-02	-5.1545E+02	2.7749E+02	.0000E+00	-1.1278E-03	2.9054E-03	.0000E+00	-3.6430E-03
700	-1.0800E+03	2.8750E+02	-4.1581E-02	-5.2368E+02	2.8192E+02	.0000E+00	-1.1446E-03	2.9312E-03	.0000E+00	-3.6923E-03
710	-1.0440E+03	2.7875E+02	-4.2041E-02	-5.3187E+02	2.8632E+02	.0000E+00	-1.1613E-03	2.9568E-03	.0000E+00	-3.7415E-03
720	-1.0080E+03	2.7000E+02	-4.2500E-02	-5.4001E+02	2.9071E+02	.0000E+00	-1.1778E-03	2.9820E-03	.0000E+00	-3.7903E-03
730	-9.7200E+02	2.6125E+02	-4.2956E-02	-5.4810E+02	2.9506E+02	.0000E+00	-1.1943E-03	3.0069E-03	.0000E+00	-3.8390E-03
740	-9.3600E+02	2.5250E+02	-4.3350E-02	-5.5546E+02	2.9903E+02	.0000E+00	-1.2091E-03	3.0316E-03	.0000E+00	-3.8859E-03
750	-9.0000E+02	2.4375E+02	-4.3730E-02	-5.6263E+02	3.0289E+02	.0000E+00	-1.2236E-03	3.0560E-03	.0000E+00	-3.9324E-03
760	-8.6400E+02	2.3500E+02	-4.4108E-02	-5.6974E+02	3.0672E+02	.0000E+00	-1.2379E-03	3.0801E-03	.0000E+00	-3.9785E-03
770	-8.2800E+02	2.2625E+02	-4.4481E-02	-5.7678E+02	3.1051E+02	.0000E+00	-1.2520E-03	3.1039E-03	.0000E+00	-4.0244E-03
780	-7.9200E+02	2.1750E+02	-4.4852E-02	-5.8376E+02	3.1426E+02	.0000E+00	-1.2660E-03	3.1273E-03	.0000E+00	-4.0700E-03
790	-7.5600E+02	2.0875E+02	-4.5219E-02	-5.9066E+02	3.1798E+02	.0000E+00	-1.2798E-03	3.1504E-03	.0000E+00	-4.1153E-03
800	-7.2000E+02	2.0000E+02	-4.5581E-02	-5.9745E+02	3.2163E+02	.0000E+00	-1.2933E-03	3.1730E-03	.0000E+00	-4.1605E-03
810	-6.8400E+02	1.9125E+02	-4.5936E-02	-6.0411E+02	3.2522E+02	.0000E+00	-1.3065E-03	3.1951E-03	.0000E+00	-4.2057E-03
820	-6.4800E+02	1.8250E+02	-4.6288E-02	-6.1070E+02	3.2877E+02	.0000E+00	-1.3195E-03	3.2168E-03	.0000E+00	-4.2506E-03
830	-6.1200E+02	1.7375E+02	-4.6636E-02	-6.1723E+02	3.3228E+02	.0000E+00	-1.3324E-03	3.2382E-03	.0000E+00	-4.2952E-03
840	-5.7600E+02	1.6500E+02	-4.6981E-02	-6.2367E+02	3.3575E+02	.0000E+00	-1.3451E-03	3.2593E-03	.0000E+00	-4.3395E-03
850	-5.4000E+02	1.5625E+02	-4.7323E-02	-6.3005E+02	3.3918E+02	.0000E+00	-1.3576E-03	3.2800E-03	.0000E+00	-4.3836E-03
860	-5.0400E+02	1.4750E+02	-4.7660E-02	-6.3635E+02	3.4258E+02	.0000E+00	-1.3699E-03	3.3004E-03	.0000E+00	-4.4274E-03
870	-4.6800E+02	1.3875E+02	-4.7995E-02	-6.4258E+02	3.4593E+02	.0000E+00	-1.3821E-03	3.3205E-03	.0000E+00	-4.4709E-03
880	-4.3200E+02	1.3000E+02	-4.8325E-02	-6.4874E+02	3.4925E+02	.0000E+00	-1.3941E-03	3.3403E-03	.0000E+00	-4.5141E-03
890	-3.9600E+02	1.2125E+02	-4.8653E-02	-6.5482E+02	3.5252E+02	.0000E+00	-1.4059E-03	3.3597E-03	.0000E+00	-4.5571E-03
900	-3.6000E+02	1.1250E+02	-4.8976E-02	-6.6083E+02	3.5576E+02	.0000E+00	-1.4175E-03	3.3788E-03	.0000E+00	-4.5998E-03
910	-3.2400E+02	1.0375E+02	-4.9296E-02	-6.6676E+02	3.5895E+02	.0000E+00	-1.4290E-03	3.3976E-03	.0000E+00	-4.6422E-03
920	-2.8800E+02	9.5000E+01	-4.9612E-02	-6.7262E+02	3.6211E+02	.0000E+00	-1.4402E-03	3.4160E-03	.0000E+00	-4.6844E-03
930	-2.5200E+02	8.6250E+01	-4.9920E-02	-6.7833E+02	3.6518E+02	.0000E+00	-1.4510E-03	3.4338E-03	.0000E+00	-4.7265E-03
940	-2.1600E+02	7.7500E+01	-5.0223E-02	-6.8394E+02	3.6820E+02	.0000E+00	-1.4616E-03	3.4512E-03	.0000E+00	-4.7685E-03
950	-1.8000E+02	6.8750E+01	-5.0522E-02	-6.8947E+02	3.7118E+02	.0000E+00	-1.4719E-03	3.4683E-03	.0000E+00	-4.8101E-03
960	-1.4400E+02	6.0000E+01	-5.0818E-02	-6.9492E+02	3.7411E+02	.0000E+00	-1.4821E-03	3.4851E-03	.0000E+00	-4.8516E-03
970	-1.0800E+02	5.1250E+01	-5.1109E-02	-7.0030E+02	3.7700E+02	.0000E+00	-1.4921E-03	3.5015E-03	.0000E+00	-4.8927E-03
980	-7.2000E+01	4.2500E+01	-5.1397E-02	-7.0559E+02	3.7986E+02	.0000E+00	-1.5019E-03	3.5176E-03	.0000E+00	-4.9336E-03
990	-3.6000E+01	3.3750E+01	-5.1680E-02	-7.1081E+02	3.8266E+02	.0000E+00	-1.5115E-03	3.5333E-03	.0000E+00	-4.9742E-03
1000	.0000E+00	2.5000E+01	-5.1960E-02	-7.1595E+02	3.8543E+02	.0000E+00	-1.5209E-03	3.5487E-03	.0000E+00	-5.0145E-03
1010	1.8000E+01	3.7500E+01	-1.1729E+02	-9.2625E+02	3.1831E+02	.0000E+00	-2.0651E-03	2.9689E-03	.0000E+00	-5.5145E-03
1020	3.6000E+01	5.0000E+01	-2.3428E+02	-1.1360E+03	2.5127E+02	.0000E+00	-2.6095E-03	2.3878E-03	.0000E+00	-6.0145E-03
1030	5.4000E+01	6.2500E+01	-3.5104E+02	-1.3453E+03	1.8433E+02	.0000E+00	-3.1540E-03	1.8055E-03	.0000E+00	-6.5145E-03
1040	7.2000E+01	7.5000E+01	-4.6755E+02	-1.5540E+03	1.1748E+02	.0000E+00	-3.6987E-03	1.2220E-03	.0000E+00	-7.0145E-03
1050	9.0000E+01	8.7500E+01	-5.8381E+02	-1.7622E+03	5.0719E+01	.0000E+00	-4.2436E-03	6.3724E-04	.0000E+00	-7.5145E-03
1060	1.0800E+02	1.0000E+02	-6.9983E+02	-1.9699E+03	-1.5958E+01	.0000E+00	-4.7881E-03	5.1252E-05	.0000E+00	-8.0145E-03
1070	1.2600E+02	1.1250E+02	-8.1561E+02	-2.1770E+03	-8.2550E+01	.0000E+00	-5.3323E-03	-5.3597E-04	.0000E+00	-8.5145E-03

1080	1.4400E+02	1.2500E+02	-9.3118E+02	-2.3837E+03	-1.4905E+02	.0000E+00	-5.8767E-03	-1.1244E-03	.0000E+00	-9.0145E-03
1090	1.6200E+02	1.3750E+02	-1.0465E+03	-2.5900E+03	-2.1545E+02	.0000E+00	-6.4213E-03	-1.7141E-03	.0000E+00	-9.5145E-03
1100	1.8000E+02	1.5000E+02	-1.1617E+03	-2.7958E+03	-2.8175E+02	.0000E+00	-6.9661E-03	-2.3050E-03	.0000E+00	-1.0015E-02
1110	1.9800E+02	2.0000E+02	-1.0013E+03	-2.4622E+03	-2.1457E+02	.0000E+00	-6.1473E-03	-1.6810E-03	.0000E+00	-9.0145E-03
1120	2.1600E+02	2.5000E+02	-8.4403E+02	-2.1312E+03	-1.5096E+02	.0000E+00	-5.3286E-03	-1.0767E-03	.0000E+00	-8.0145E-03
1130	2.3400E+02	3.0000E+02	-6.9027E+02	-1.8033E+03	-9.0978E+01	.0000E+00	-4.5133E-03	-4.9860E-04	.0000E+00	-7.0145E-03
1140	2.5200E+02	3.5000E+02	-5.4051E+02	-1.4788E+03	-3.5300E+01	.0000E+00	-3.7009E-03	5.7233E-05	.0000E+00	-6.0145E-03
1150	2.7000E+02	4.0000E+02	-3.9496E+02	-1.1580E+03	1.5921E+01	.0000E+00	-2.8920E-03	5.9285E-04	.0000E+00	-5.0145E-03
1160	2.8800E+02	4.5000E+02	-2.5388E+02	-8.4133E+02	6.2438E+01	.0000E+00	-2.0870E-03	1.1088E-03	.0000E+00	-4.0145E-03
1170	3.0600E+02	5.0000E+02	-1.1741E+02	-5.2873E+02	1.0407E+02	.0000E+00	-1.2858E-03	1.6055E-03	.0000E+00	-3.0145E-03
1180	3.2400E+02	5.5000E+02	1.4293E+01	-2.2038E+02	1.4065E+02	.0000E+00	-4.8856E-04	2.0840E-03	.0000E+00	-2.0145E-03
1190	3.4200E+02	6.0000E+02	1.3669E+02	8.4794E+01	1.6464E+02	.0000E+00	3.0443E-04	2.5450E-03	.0000E+00	-1.0145E-03
1200	3.6000E+02	6.5000E+02	2.4791E+02	3.8597E+02	1.7357E+02	.0000E+00	1.0937E-03	2.9890E-03	.0000E+00	-1.4547E-05
1210	3.7800E+02	6.0000E+02	1.2387E+02	8.6754E+01	1.4385E+02	.0000E+00	3.0443E-04	2.5450E-03	.0000E+00	-1.0145E-03
1220	3.9600E+02	5.5000E+02	-3.6230E+00	-2.1704E+02	1.1129E+02	.0000E+00	-4.8856E-04	2.0840E-03	.0000E+00	-2.0145E-03
1230	4.1400E+02	5.0000E+02	-1.3593E+02	-5.2529E+02	7.3718E+01	.0000E+00	-1.2858E-03	1.6055E-03	.0000E+00	-3.0145E-03
1240	4.3200E+02	4.5000E+02	-2.7294E+02	-8.3779E+02	3.1208E+01	.0000E+00	-2.0870E-03	1.1088E-03	.0000E+00	-4.0145E-03
1250	4.5000E+02	4.0000E+02	-4.1451E+02	-1.1544E+03	-1.6102E+01	.0000E+00	-2.8920E-03	5.9285E-04	.0000E+00	-5.0145E-03
1260	4.6800E+02	3.5000E+02	-5.6049E+02	-1.4751E+03	-6.8032E+01	.0000E+00	-3.7009E-03	5.7233E-05	.0000E+00	-6.0145E-03
1270	4.8600E+02	3.0000E+02	-7.1062E+02	-1.7995E+03	-1.2431E+02	.0000E+00	-4.5133E-03	-4.9860E-04	.0000E+00	-7.0145E-03
1280	5.0400E+02	2.5000E+02	-8.6467E+02	-2.1274E+03	-1.8477E+02	.0000E+00	-5.3286E-03	-1.0767E-03	.0000E+00	-8.0145E-03
1290	5.2200E+02	2.0000E+02	-1.0221E+03	-2.4584E+03	-2.4865E+02	.0000E+00	-6.1473E-03	-1.6810E-03	.0000E+00	-9.0145E-03
1300	5.4000E+02	1.5000E+02	-1.1826E+03	-2.7919E+03	-3.1609E+02	.0000E+00	-6.9661E-03	-2.3050E-03	.0000E+00	-1.0015E-02
1310	5.5800E+02	2.0000E+02	-1.0221E+03	-2.4584E+03	-2.4865E+02	.0000E+00	-6.1473E-03	-1.6810E-03	.0000E+00	-9.0145E-03
1320	5.7600E+02	2.5000E+02	-8.6467E+02	-2.1274E+03	-1.8477E+02	.0000E+00	-5.3286E-03	-1.0767E-03	.0000E+00	-8.0145E-03
1330	5.9400E+02	3.0000E+02	-7.1062E+02	-1.7995E+03	-1.2431E+02	.0000E+00	-4.5133E-03	-4.9860E-04	.0000E+00	-7.0145E-03
1340	6.1200E+02	3.5000E+02	-5.6049E+02	-1.4751E+03	-6.8032E+01	.0000E+00	-3.7009E-03	5.7233E-05	.0000E+00	-6.0145E-03
1350	6.3000E+02	4.0000E+02	-4.1451E+02	-1.1544E+03	-1.6102E+01	.0000E+00	-2.8920E-03	5.9285E-04	.0000E+00	-5.0145E-03
1360	6.4800E+02	4.5000E+02	-2.7294E+02	-8.3779E+02	3.1208E+01	.0000E+00	-2.0870E-03	1.1088E-03	.0000E+00	-4.0145E-03
1370	6.6600E+02	5.0000E+02	-1.3593E+02	-5.2529E+02	7.3718E+01	.0000E+00	-1.2858E-03	1.6055E-03	.0000E+00	-3.0145E-03
1380	6.8400E+02	5.5000E+02	-3.6230E+00	-2.1704E+02	1.1129E+02	.0000E+00	-4.8856E-04	2.0840E-03	.0000E+00	-2.0145E-03
1390	7.0200E+02	6.0000E+02	1.2367E+02	8.6866E+01	1.4349E+02	.0000E+00	3.0443E-04	2.5450E-03	.0000E+00	-1.0145E-03
1400	7.2000E+02	6.5000E+02	2.3884E+02	3.8750E+02	1.5880E+02	.0000E+00	1.0937E-03	2.9890E-03	.0000E+00	-1.4547E-05
1410	7.3800E+02	6.0000E+02	1.1526E+02	8.8192E+01	1.2983E+02	.0000E+00	3.0443E-04	2.5450E-03	.0000E+00	-1.0145E-03
1420	7.5600E+02	5.5000E+02	-1.2562E+01	-2.1555E+02	9.6739E+01	.0000E+00	-4.8856E-04	2.0840E-03	.0000E+00	-2.0145E-03
1430	7.7400E+02	5.0000E+02	-1.4518E+02	-5.2375E+02	5.8672E+01	.0000E+00	-1.2858E-03	1.6055E-03	.0000E+00	-3.0145E-03
1440	7.9200E+02	4.5000E+02	-2.8245E+02	-8.3621E+02	1.5726E+01	.0000E+00	-2.0870E-03	1.1088E-03	.0000E+00	-4.0145E-03
1450	8.1000E+02	4.0000E+02	-4.2426E+02	-1.1528E+03	-3.1977E+01	.0000E+00	-2.8920E-03	5.9285E-04	.0000E+00	-5.0145E-03
1460	8.2800E+02	3.5000E+02	-5.7046E+02	-1.4734E+03	-8.4259E+01	.0000E+00	-3.7009E-03	5.7233E-05	.0000E+00	-6.0145E-03
1470	8.4600E+02	3.0000E+02	-7.2077E+02	-1.7978E+03	-1.4083E+02	.0000E+00	-4.5133E-03	-4.9860E-04	.0000E+00	-7.0145E-03
1480	8.6400E+02	2.5000E+02	-8.7497E+02	-2.1256E+03	-2.0153E+02	.0000E+00	-5.3286E-03	-1.0767E-03	.0000E+00	-8.0145E-03
1490	8.8200E+02	2.0000E+02	-1.0324E+03	-2.4567E+03	-2.6554E+02	.0000E+00	-6.1473E-03	-1.6810E-03	.0000E+00	-9.0145E-03
1500	9.0000E+02	1.5000E+02	-1.1931E+03	-2.7902E+03	-3.3311E+02	.0000E+00	-6.9661E-03	-2.3050E-03	.0000E+00	-1.0015E-02
1510	9.1800E+02	2.0000E+02	-1.0324E+03	-2.4567E+03	-2.6554E+02	.0000E+00	-6.1473E-03	-1.6810E-03	.0000E+00	-9.0145E-03
1520	9.3600E+02	2.5000E+02	-8.7497E+02	-2.1256E+03	-2.0153E+02	.0000E+00	-5.3286E-03	-1.0767E-03	.0000E+00	-8.0145E-03
1530	9.5400E+02	3.0000E+02	-7.2077E+02	-1.7978E+03	-1.4083E+02	.0000E+00	-4.5133E-03	-4.9860E-04	.0000E+00	-7.0145E-03
1540	9.7200E+02	3.5000E+02	-5.7046E+02	-1.4734E+03	-8.4259E+01	.0000E+00	-3.7009E-03	5.7233E-05	.0000E+00	-6.0145E-03
1550	9.9000E+02	4.0000E+02	-4.2426E+02	-1.1528E+03	-3.1977E+01	.0000E+00	-2.8920E-03	5.9285E-04	.0000E+00	-5.0145E-03
1560	1.0080E+03	4.5000E+02	-2.8245E+02	-8.3621E+02	1.5726E+01	.0000E+00	-2.0870E-03	1.1088E-03	.0000E+00	-4.0145E-03
1570	1.0260E+03	5.0000E+02	-1.4518E+02	-5.2375E+02	5.8672E+01	.0000E+00	-1.2858E-03	1.6055E-03	.0000E+00	-3.0145E-03
1580	1.0440E+03	5.5000E+02	-1.2562E+01	-2.1555E+02	9.6739E+01	.0000E+00	-4.8856E-04	2.0840E-03	.0000E+00	-2.0145E-03
1590	1.0620E+03	6.0000E+02	1.1524E+02	8.8206E+01	1.2979E+02	.0000E+00	3.0443E-04	2.5450E-03	.0000E+00	-1.0145E-03
1600	1.0800E+03	6.5000E+02	2.3277E+02	3.8848E+02	1.4892E+02	.0000E+00	1.0937E-03	2.9890E-03	.0000E+00	-1.4547E-05
1610	1.0980E+03	6.0000E+02	1.0919E+02	8.9172E+01	1.1996E+02	.0000E+00	3.0443E-04	2.5450E-03	.0000E+00	-1.0145E-03
1620	1.1160E+03	5.5000E+02	-1.8867E+01	-2.1453E+02	8.6493E+01	.0000E+00	-4.8856E-04	2.0840E-03	.0000E+00	-2.0145E-03
1630	1.1340E+03	5.0000E+02	-1.5169E+02	-5.2270E+02	4.8080E+01	.0000E+00	-1.2858E-03	1.6055E-03	.0000E+00	-3.0145E-03
1640	1.1520E+03	4.5000E+02	-2.8916E+02	-8.3513E+02	4.8278E+00	.0000E+00	-2.0870E-03	1.1088E-03	.0000E+00	-4.0145E-03
1650	1.1700E+03	4.0000E+02	-4.3114E+02	-1.1517E+03	-4.3153E+01	.0000E+00	-2.8920E-03	5.9285E-04	.0000E+00	-5.0145E-03
1660	1.1880E+03	3.5000E+02	-5.7749E+02	-1.4723E+03	-9.5682E+01	.0000E+00	-3.7009E-03	5.7233E-05	.0000E+00	-6.0145E-03
1670	1.2060E+03	3.0000E+02	-7.2793E+02	-1.7967E+03	-1.5246E+02	.0000E+00	-4.5133E-03	-4.9860E-04	.0000E+00	-7.0145E-03
1680	1.2240E+03	2.5000E+02	-8.8223E+02	-2.1245E+03	-2.1333E+02	.0000E+00	-5.3286E-03	-1.0767E-03	.0000E+00	-8.0145E-03

1690	1.2420E+03	2.0000E+02	-1.0398E+03	-2.4555E+03	-2.7743E+02	.0000E+00	-6.1473E-03	-1.6810E-03	.0000E+00	-9.0145E-03
1700	1.2600E+03	1.5000E+02	-1.2005E+03	-2.7890E+03	-3.4510E+02	.0000E+00	-6.9661E-03	-2.3050E-03	.0000E+00	-1.0015E-02
1710	1.2780E+03	2.0000E+02	-1.0398E+03	-2.4555E+03	-2.7743E+02	.0000E+00	-6.1473E-03	-1.6810E-03	.0000E+00	-9.0145E-03
1720	1.2960E+03	2.5000E+02	-8.8223E+02	-2.1245E+03	-2.1333E+02	.0000E+00	-5.3286E-03	-1.0767E-03	.0000E+00	-8.0145E-03
1730	1.3140E+03	3.0000E+02	-7.2793E+02	-1.7967E+03	-1.5246E+02	.0000E+00	-4.5133E-03	-4.9860E-04	.0000E+00	-7.0145E-03
1740	1.3320E+03	3.5000E+02	-5.7749E+02	-1.4723E+03	-9.5682E+01	.0000E+00	-3.7009E-03	5.7233E-05	.0000E+00	-6.0145E-03
1750	1.3500E+03	4.0000E+02	-4.3114E+02	-1.1517E+03	-4.3153E+01	.0000E+00	-2.8920E-03	5.9285E-04	.0000E+00	-5.0145E-03
1760	1.3680E+03	4.5000E+02	-2.8916E+02	-8.3513E+02	4.8278E+00	.0000E+00	-2.0870E-03	1.1088E-03	.0000E+00	-4.0145E-03
1770	1.3860E+03	5.0000E+02	-1.5169E+02	-5.2270E+02	4.8080E+01	.0000E+00	-1.2858E-03	1.6055E-03	.0000E+00	-3.0145E-03
1780	1.4040E+03	5.5000E+02	-1.8867E+01	-2.1453E+02	8.6493E+01	.0000E+00	-4.8856E-04	2.0840E-03	.0000E+00	-2.0145E-03
1790	1.4220E+03	6.0000E+02	1.0918E+02	8.9174E+01	1.1996E+02	.0000E+00	3.0443E-04	2.5450E-03	.0000E+00	-1.0145E-03
1800	1.4400E+03	6.5000E+02	2.2833E+02	3.8917E+02	1.4172E+02	.0000E+00	1.0937E-03	2.9890E-03	.0000E+00	-1.4547E-05
1810	1.4580E+03	6.0000E+02	1.0465E+02	8.9880E+01	1.1260E+02	.0000E+00	3.0443E-04	2.5450E-03	.0000E+00	-1.0145E-03
1820	1.4760E+03	5.5000E+02	-2.3578E+01	-2.1380E+02	7.8850E+01	.0000E+00	-4.8856E-04	2.0840E-03	.0000E+00	-2.0145E-03
1830	1.4940E+03	5.0000E+02	-1.5656E+02	-5.2195E+02	4.0180E+01	.0000E+00	-1.2858E-03	1.6055E-03	.0000E+00	-3.0145E-03
1840	1.5120E+03	4.5000E+02	-2.9417E+02	-8.3435E+02	-3.3016E+00	.0000E+00	-2.0870E-03	1.1088E-03	.0000E+00	-4.0145E-03
1850	1.5300E+03	4.0000E+02	-4.3628E+02	-1.1509E+03	-5.1489E+01	.0000E+00	-2.8920E-03	5.9285E-04	.0000E+00	-5.0145E-03
1860	1.5480E+03	3.5000E+02	-5.8274E+02	-1.4715E+03	-1.0420E+02	.0000E+00	-3.7009E-03	5.7233E-05	.0000E+00	-6.0145E-03
1870	1.5660E+03	3.0000E+02	-7.3328E+02	-1.7958E+03	-1.6114E+02	.0000E+00	-4.5133E-03	-4.9860E-04	.0000E+00	-7.0145E-03
1880	1.5840E+03	2.5000E+02	-8.8766E+02	-2.1236E+03	-2.2213E+02	.0000E+00	-5.3286E-03	-1.0767E-03	.0000E+00	-8.0145E-03
1890	1.6020E+03	2.0000E+02	-1.0452E+03	-2.4547E+03	-2.8630E+02	.0000E+00	-6.1473E-03	-1.6810E-03	.0000E+00	-9.0145E-03
1900	1.6200E+03	1.5000E+02	-1.2060E+03	-2.7882E+03	-3.5404E+02	.0000E+00	-6.9661E-03	-2.3050E-03	.0000E+00	-1.0015E-02
1910	1.6380E+03	2.0000E+02	-1.0452E+03	-2.4547E+03	-2.8630E+02	.0000E+00	-6.1473E-03	-1.6810E-03	.0000E+00	-9.0145E-03
1920	1.6560E+03	2.5000E+02	-8.8766E+02	-2.1236E+03	-2.2213E+02	.0000E+00	-5.3286E-03	-1.0767E-03	.0000E+00	-8.0145E-03
1930	1.6740E+03	3.0000E+02	-7.3328E+02	-1.7958E+03	-1.6114E+02	.0000E+00	-4.5133E-03	-4.9860E-04	.0000E+00	-7.0145E-03
1940	1.6920E+03	3.5000E+02	-5.8274E+02	-1.4715E+03	-1.0420E+02	.0000E+00	-3.7009E-03	5.7233E-05	.0000E+00	-6.0145E-03
1950	1.7100E+03	4.0000E+02	-4.3628E+02	-1.1509E+03	-5.1489E+01	.0000E+00	-2.8920E-03	5.9285E-04	.0000E+00	-5.0145E-03
1960	1.7280E+03	4.5000E+02	-2.9417E+02	-8.3435E+02	-3.3016E+00	.0000E+00	-2.0870E-03	1.1088E-03	.0000E+00	-4.0145E-03
1970	1.7460E+03	5.0000E+02	-1.5656E+02	-5.2195E+02	4.0180E+01	.0000E+00	-1.2858E-03	1.6055E-03	.0000E+00	-3.0145E-03
1980	1.7640E+03	5.5000E+02	-2.3578E+01	-2.1380E+02	7.8850E+01	.0000E+00	-4.8856E-04	2.0840E-03	.0000E+00	-2.0145E-03
1990	1.7820E+03	6.0000E+02	1.0465E+02	8.9880E+01	1.1260E+02	.0000E+00	3.0443E-04	2.5450E-03	.0000E+00	-1.0145E-03
2000	1.8000E+03	6.5000E+02	2.2488E+02	3.8969E+02	1.3614E+02	.0000E+00	1.0937E-03	2.9890E-03	.0000E+00	-1.4547E-05
2010	1.8180E+03	6.0000E+02	1.0111E+02	9.0413E+01	1.0688E+02	.0000E+00	3.0443E-04	2.5450E-03	.0000E+00	-1.0145E-03
2020	1.8360E+03	5.5000E+02	-2.7249E+01	-2.1325E+02	7.2905E+01	.0000E+00	-4.8856E-04	2.0840E-03	.0000E+00	-2.0145E-03
2030	1.8540E+03	5.0000E+02	-1.6036E+02	-5.2138E+02	3.4034E+01	.0000E+00	-1.2858E-03	1.6055E-03	.0000E+00	-3.0145E-03
2040	1.8720E+03	4.5000E+02	-2.9808E+02	-8.3377E+02	-9.6252E+00	.0000E+00	-2.0870E-03	1.1088E-03	.0000E+00	-4.0145E-03
2050	1.8900E+03	4.0000E+02	-4.4028E+02	-1.1503E+03	-5.7973E+01	.0000E+00	-2.8920E-03	5.9285E-04	.0000E+00	-5.0145E-03
2060	1.9080E+03	3.5000E+02	-5.8684E+02	-1.4709E+03	-1.1083E+02	.0000E+00	-3.7009E-03	5.7233E-05	.0000E+00	-6.0145E-03
2070	1.9260E+03	3.0000E+02	-7.3745E+02	-1.7952E+03	-1.6789E+02	.0000E+00	-4.5133E-03	-4.9860E-04	.0000E+00	-7.0145E-03
2080	1.9440E+03	2.5000E+02	-8.9189E+02	-2.1230E+03	-2.2898E+02	.0000E+00	-5.3286E-03	-1.0767E-03	.0000E+00	-8.0145E-03
2090	1.9620E+03	2.0000E+02	-1.0495E+03	-2.4540E+03	-2.9320E+02	.0000E+00	-6.1473E-03	-1.6810E-03	.0000E+00	-9.0145E-03
2100	1.9800E+03	1.5000E+02	-1.2103E+03	-2.7875E+03	-3.6099E+02	.0000E+00	-6.9661E-03	-2.3050E-03	.0000E+00	-1.0015E-02

```
   ************************************
   *                                  *
   *   F I D E P 2 - VERSION 6        *
   *                                  *
   ************************************

  ************ PROBLEM TITLE ************
SCS-6/TIMETAL21S(DBP) Inphase TMF - stress control
  ************ GEOMETRY TYPE ************
     Concentric Cylinder Model
  ************ LOADING TYPE ************
      Stress Control
  ********* LOADING HISTORY ************
  POINTS IN HISTORY  13
      Step          Time      Temperature  Axial Stress  Radial Stress
     .0000E+00  -3.6000E+03   9.0000E+02    .0000E+00    .0000E+00
    1.0000E+03    .0000E+00   2.5000E+01    .0000E+00    .0000E+00
    1.2000E+03   1.8000E+02   1.5000E+02   5.0000E+01    .0000E+00
    1.4000E+03   3.6000E+02   6.5000E+02   5.0000E+02    .0000E+00
    1.6000E+03   5.4000E+02   1.5000E+02   5.0000E+01    .0000E+00
    1.8000E+03   7.2000E+02   6.5000E+02   5.0000E+02    .0000E+00
    2.0000E+03   9.0000E+02   1.5000E+02   5.0000E+01    .0000E+00
    2.2000E+03   1.0800E+03   6.5000E+02   5.0000E+02    .0000E+00
    2.4000E+03   1.2600E+03   1.5000E+02   5.0000E+01    .0000E+00
    2.6000E+03   1.4400E+03   6.5000E+02   5.0000E+02    .0000E+00
    2.8000E+03   1.6200E+03   1.5000E+02   5.0000E+01    .0000E+00
    3.0000E+03   1.8000E+03   6.5000E+02   5.0000E+02    .0000E+00
    3.2000E+03   1.9800E+03   1.5000E+02   5.0000E+01    .0000E+00
  ********* GEOMETRY INFORMATION  ***********
  Number of Cells  2
       For Cell Number : 1
            Material Number :  1
            Volume Fraction :  .35
            Nodes in cell   :  5
       For Cell Number : 2
            Material Number :  4
            Volume Fraction :  .65
            Nodes in cell   :  15
  ********** OUTPUT INFORMATION  ************
  Output at Interface for Material:  2
  ********** MATERIAL INFORMATION  ************
  Material for Cell Number :  1
```

Thermo-Elastic Response for SCS-6 fiber

Constitutive model: Elastic

---------- MATERIAL PROPERTIES ----------

T(C)	E(GPa)	NU	CTE(1E-6/C)
2.1110E+01	3.9300E+02	2.5000E-01	3.9907E+00
9.3330E+01	3.9000E+02	2.5000E-01	4.0289E+00
2.0444E+02	3.8600E+02	2.5000E-01	4.0989E+00
3.1556E+02	3.8200E+02	2.5000E-01	4.1801E+00
4.2667E+02	3.7800E+02	2.5000E-01	4.2655E+00
5.3778E+02	3.7400E+02	2.5000E-01	4.3510E+00
6.4889E+02	3.7000E+02	2.5000E-01	4.4324E+00
7.6000E+02	3.6500E+02	2.5000E-01	4.5074E+00
8.7111E+02	3.6100E+02	2.5000E-01	4.5718E+00
1.0933E+03	3.5400E+02	2.5000E-01	4.5723E+00

Reference Temperature = 900.0

Material for Cell Number : 2

Bodner-Partom Theory with Directional Hardening for TimetalÒ21S

Constitutive model: Bodner-Partom with Directional Hardening

---------- MATERIAL PROPERTIES ----------

T(C)	E(GPa)	NU	CTE(1E-6/C)
2.3000E+01	1.1200E+02	3.4000E-01	9.7787E+00
2.6000E+02	1.0800E+02	3.4000E-01	1.0713E+01
3.1500E+02	1.0610E+02	3.4000E-01	1.0915E+01
3.6500E+02	1.0410E+02	3.4000E-01	1.1093E+01
4.1500E+02	1.0170E+02	3.4000E-01	1.1267E+01
4.6500E+02	9.9090E+01	3.4000E-01	1.1436E+01
4.8200E+02	9.8110E+01	3.4000E-01	1.1492E+01
5.0000E+02	9.7050E+01	3.4000E-01	1.1550E+01
5.2500E+02	9.5500E+01	3.4000E-01	1.1631E+01
5.5000E+02	9.3870E+01	3.4000E-01	1.1710E+01
5.7500E+02	9.2170E+01	3.4000E-01	1.1788E+01
6.0000E+02	9.0400E+01	3.4000E-01	1.1865E+01
6.5000E+02	8.6610E+01	3.4000E-01	1.2014E+01
7.6000E+02	7.7220E+01	3.4000E-01	1.2323E+01
8.1500E+02	7.1960E+01	3.4000E-01	1.2467E+01
9.0000E+02	6.3120E+01	3.4000E-01	1.2689E+01

Reference Temperature = 900.0

T(C)	N	Z0=Z2(1/S)	Z3(MPa)	M2(1/MPa)	
2.3000E+01	4.8000E+00	1.5500E+03	1.0000E+02	3.5000E-01	
2.6000E+02	3.5000E+00	1.3000E+03	3.0000E+02	3.5000E-01	
3.1500E+02	3.0540E+00	1.2504E+03	3.9000E+02	1.5020E+00	
3.6500E+02	2.6490E+00	1.2054E+03	5.0000E+02	2.5490E+00	
4.1500E+02	2.2430E+00	1.1604E+03	6.6000E+02	3.5970E+00	
4.6500E+02	1.8380E+00	1.1153E+03	9.6000E+02	4.6440E+00	
4.8200E+02	1.7000E+00	1.1000E+03	1.1000E+03	5.0000E+00	
5.0000E+02	1.5000E+00	1.0893E+03	1.3000E+03	5.7630E+00	
5.2500E+02	1.2800E+00	1.0744E+03	1.6700E+03	6.8220E+00	
5.5000E+02	1.1000E+00	1.0595E+03	2.1000E+03	7.8810E+00	
5.7500E+02	9.7000E-01	1.0446E+03	2.6000E+03	8.9410E+00	
6.0000E+02	8.2000E-01	1.0298E+03	3.7000E+03	1.0000E+01	

```
   6.5000E+02   7.4000E-01   1.0000E+03   3.8000E+03   1.0000E+01
   7.6000E+02   5.8000E-01   6.0000E+02   4.0000E+03   1.5000E+01
   8.1500E+02   5.5000E-01   3.0000E+02   4.1000E+03   3.0000E+01
   9.0000E+02   5.5000E-01   3.0000E+02   4.3000E+03   3.0000E+01
  ----------------------------------------

A1=A2      M1          Z1          R1=R2       DO
 -9999.0 .0 1600.0 3.0 10000.0
  ----------------------------------------

  -------------------- OUTPUT -------------------
```

STEP	TIME	TEMPERATRE	Seff	Srad	Stan	Sz	Erad	Etan	Ez
1	-3.5964E+03	8.9913E+02	7.1692E-01	-2.4595E-01	5.1101E-01	4.2275E-01	-8.9135E-06	7.1332E-06	5.2622E-06
10	-3.5640E+03	8.9125E+02	7.2351E+00	-2.4833E+00	5.1594E+00	4.2599E+00	-8.8801E-05	7.1144E-05	5.2320E-05
20	-3.5280E+03	8.8250E+02	1.1759E+01	-4.5688E+00	7.7945E+00	6.4744E+00	-1.9987E-04	1.4231E-04	1.0536E-04
30	-3.4920E+03	8.7375E+02	1.4255E+01	-5.6047E+00	9.2258E+00	7.9933E+00	-3.2153E-04	2.1320E-04	1.6477E-04
40	-3.4560E+03	8.6500E+02	1.5162E+01	-6.2023E+00	9.4262E+00	8.4442E+00	-4.5489E-04	2.8380E-04	2.2702E-04
50	-3.4200E+03	8.5625E+02	1.5414E+01	-6.4495E+00	9.3042E+00	8.5988E+00	-5.9180E-04	3.5399E-04	2.9198E-04
60	-3.3840E+03	8.4750E+02	1.5524E+01	-6.5302E+00	9.2247E+00	8.7514E+00	-7.2896E-04	4.2363E-04	3.5874E-04
70	-3.3480E+03	8.3875E+02	1.5725E+01	-6.5691E+00	9.3114E+00	8.9948E+00	-8.6490E-04	4.9278E-04	4.2616E-04
80	-3.3120E+03	8.3000E+02	1.5937E+01	-6.6131E+00	9.4315E+00	9.2124E+00	-1.0005E-03	5.6153E-04	4.9364E-04
90	-3.2760E+03	8.2125E+02	1.6159E+01	-6.6689E+00	9.5694E+00	9.4080E+00	-1.1356E-03	6.2991E-04	5.6096E-04
100	-3.2400E+03	8.1250E+02	1.6631E+01	-6.8398E+00	9.8773E+00	9.7025E+00	-1.2687E-03	6.9798E-04	6.2716E-04
110	-3.2040E+03	8.0375E+02	1.8558E+01	-7.6243E+00	1.1134E+01	1.0726E+01	-1.3917E-03	7.6587E-04	6.8824E-04
120	-3.1680E+03	7.9500E+02	2.0887E+01	-8.5998E+00	1.2610E+01	1.1947E+01	-1.5118E-03	8.3354E-04	7.4737E-04
130	-3.1320E+03	7.8625E+02	2.3369E+01	-9.6604E+00	1.4152E+01	1.3238E+01	-1.6304E-03	9.0096E-04	8.0537E-04
140	-3.0960E+03	7.7750E+02	2.5948E+01	-1.0776E+01	1.5730E+01	1.4574E+01	-1.7479E-03	9.6811E-04	8.6252E-04
150	-3.0600E+03	7.6875E+02	2.8604E+01	-1.1933E+01	1.7343E+01	1.5946E+01	-1.8645E-03	1.0350E-03	9.1896E-04
160	-3.0240E+03	7.6000E+02	3.1324E+01	-1.3126E+01	1.8984E+01	1.7347E+01	-1.9802E-03	1.1016E-03	9.7477E-04
170	-2.9880E+03	7.5125E+02	3.4749E+01	-1.4585E+01	2.1123E+01	1.9116E+01	-2.0908E-03	1.1677E-03	1.0284E-03
180	-2.9520E+03	7.4250E+02	3.8661E+01	-1.6233E+01	2.3599E+01	2.1137E+01	-2.1980E-03	1.2335E-03	1.0803E-03
190	-2.9160E+03	7.3375E+02	4.2944E+01	-1.8032E+01	2.6324E+01	2.3344E+01	-2.3026E-03	1.2990E-03	1.1310E-03
200	-2.8800E+03	7.2500E+02	4.7547E+01	-1.9961E+01	2.9265E+01	2.5706E+01	-2.4049E-03	1.3642E-03	1.1804E-03
210	-2.8440E+03	7.1625E+02	5.2447E+01	-2.2009E+01	3.2407E+01	2.8214E+01	-2.5052E-03	1.4290E-03	1.2288E-03
220	-2.8080E+03	7.0750E+02	5.7632E+01	-2.4171E+01	3.5747E+01	3.0862E+01	-2.6035E-03	1.4935E-03	1.2762E-03
230	-2.7720E+03	6.9875E+02	6.3095E+01	-2.6441E+01	3.9281E+01	3.3647E+01	-2.6998E-03	1.5576E-03	1.3226E-03
240	-2.7360E+03	6.9000E+02	6.8831E+01	-2.8814E+01	4.3010E+01	3.6569E+01	-2.7943E-03	1.6214E-03	1.3681E-03
250	-2.7000E+03	6.8125E+02	7.4834E+01	-3.1285E+01	4.6933E+01	3.9626E+01	-2.8869E-03	1.6849E-03	1.4127E-03
260	-2.6640E+03	6.7250E+02	8.1098E+01	-3.3850E+01	5.1048E+01	4.2818E+01	-2.9778E-03	1.7480E-03	1.4566E-03
270	-2.6280E+03	6.6375E+02	8.7617E+01	-3.6504E+01	5.5354E+01	4.6142E+01	-3.0669E-03	1.8107E-03	1.4997E-03
280	-2.5920E+03	6.5500E+02	9.4385E+01	-3.9243E+01	5.9848E+01	4.9598E+01	-3.1544E-03	1.8731E-03	1.5420E-03
290	-2.5560E+03	6.4625E+02	1.0130E+02	-4.2029E+01	6.4453E+01	5.3128E+01	-3.2405E-03	1.9349E-03	1.5838E-03
300	-2.5200E+03	6.3750E+02	1.0810E+02	-4.4773E+01	6.8979E+01	5.6606E+01	-3.3263E-03	1.9964E-03	1.6253E-03
310	-2.4840E+03	6.2875E+02	1.1501E+02	-4.7539E+01	7.3601E+01	6.0158E+01	-3.4111E-03	2.0574E-03	1.6664E-03
320	-2.4480E+03	6.2000E+02	1.2205E+02	-5.0342E+01	7.8329E+01	6.3788E+01	-3.4947E-03	2.1181E-03	1.7070E-03
330	-2.4120E+03	6.1125E+02	1.2924E+02	-5.3187E+01	8.3173E+01	6.7499E+01	-3.5773E-03	2.1784E-03	1.7472E-03
340	-2.3760E+03	6.0250E+02	1.3657E+02	-5.6075E+01	8.8139E+01	7.1294E+01	-3.6586E-03	2.2384E-03	1.7869E-03
350	-2.3400E+03	5.9375E+02	1.4469E+02	-5.9138E+01	9.3789E+01	7.5597E+01	-3.7348E-03	2.2977E-03	1.8255E-03
360	-2.3040E+03	5.8500E+02	1.5359E+02	-6.2368E+01	1.0013E+02	8.0410E+01	-3.8060E-03	2.3564E-03	1.8630E-03
370	-2.2680E+03	5.7625E+02	1.6269E+02	-6.5635E+01	1.0666E+02	8.5365E+01	-3.8756E-03	2.4147E-03	1.9002E-03
380	-2.2320E+03	5.6750E+02	1.7185E+02	-6.8903E+01	1.1324E+02	9.0352E+01	-3.9444E-03	2.4725E-03	1.9370E-03
390	-2.1960E+03	5.5875E+02	1.8104E+02	-7.2185E+01	1.1986E+02	9.5363E+01	-4.0126E-03	2.5300E-03	1.9734E-03
400	-2.1600E+03	5.5000E+02	1.9029E+02	-7.5483E+01	1.2652E+02	1.0039E+02	-4.0802E-03	2.5870E-03	2.0094E-03
410	-2.1240E+03	5.4125E+02	1.9951E+02	-7.8771E+01	1.3316E+02	1.0540E+02	-4.1472E-03	2.6436E-03	2.0450E-03
420	-2.0880E+03	5.3250E+02	2.0877E+02	-8.2075E+01	1.3984E+02	1.1043E+02	-4.2137E-03	2.6998E-03	2.0804E-03
430	-2.0520E+03	5.2375E+02	2.1807E+02	-8.5389E+01	1.4655E+02	1.1547E+02	-4.2797E-03	2.7557E-03	2.1154E-03
440	-2.0160E+03	5.1500E+02	2.2731E+02	-8.8684E+01	1.5322E+02	1.2048E+02	-4.3450E-03	2.8110E-03	2.1499E-03
450	-1.9800E+03	5.0625E+02	2.3658E+02	-9.1989E+01	1.5991E+02	1.2550E+02	-4.4097E-03	2.8659E-03	2.1842E-03
460	-1.9440E+03	4.9750E+02	2.4585E+02	-9.5297E+01	1.6661E+02	1.3051E+02	-4.4740E-03	2.9204E-03	2.2181E-03
470	-1.9080E+03	4.8875E+02	2.5512E+02	-9.8599E+01	1.7330E+02	1.3552E+02	-4.5379E-03	2.9746E-03	2.2518E-03
480	-1.8720E+03	4.8000E+02	2.6439E+02	-1.0190E+02	1.8000E+02	1.4053E+02	-4.6011E-03	3.0283E-03	2.2851E-03

490	-1.8360E+03	4.7125E+02	2.7362E+02	-1.0520E+02	1.8668E+02	1.4551E+02	-4.6637E-03	3.0814E-03	2.3180E-03
500	-1.8000E+03	4.6250E+02	2.8282E+02	-1.0848E+02	1.9333E+02	1.5047E+02	-4.7256E-03	3.1341E-03	2.3505E-03
510	-1.7640E+03	4.5375E+02	2.9192E+02	-1.1171E+02	1.9991E+02	1.5538E+02	-4.7868E-03	3.1861E-03	2.3827E-03
520	-1.7280E+03	4.4500E+02	3.0101E+02	-1.1495E+02	2.0649E+02	1.6028E+02	-4.8475E-03	3.2377E-03	2.4146E-03
530	-1.6920E+03	4.3625E+02	3.1011E+02	-1.1819E+02	2.1308E+02	1.6518E+02	-4.9077E-03	3.2889E-03	2.4461E-03
540	-1.6560E+03	4.2750E+02	3.1921E+02	-1.2143E+02	2.1967E+02	1.7007E+02	-4.9673E-03	3.3397E-03	2.4773E-03
550	-1.6200E+03	4.1875E+02	3.2831E+02	-1.2468E+02	2.2626E+02	1.7496E+02	-5.0264E-03	3.3901E-03	2.5081E-03
560	-1.5840E+03	4.1000E+02	3.3731E+02	-1.2788E+02	2.3278E+02	1.7979E+02	-5.0848E-03	3.4398E-03	2.5386E-03
570	-1.5480E+03	4.0125E+02	3.4623E+02	-1.3106E+02	2.3925E+02	1.8459E+02	-5.1424E-03	3.4890E-03	2.5687E-03
580	-1.5120E+03	3.9250E+02	3.5515E+02	-1.3424E+02	2.4571E+02	1.8937E+02	-5.1995E-03	3.5377E-03	2.5985E-03
590	-1.4760E+03	3.8375E+02	3.6405E+02	-1.3741E+02	2.5217E+02	1.9414E+02	-5.2561E-03	3.5860E-03	2.6279E-03
600	-1.4400E+03	3.7500E+02	3.7294E+02	-1.4058E+02	2.5862E+02	1.9890E+02	-5.3121E-03	3.6339E-03	2.6570E-03
610	-1.4040E+03	3.6625E+02	3.8183E+02	-1.4375E+02	2.6506E+02	2.0365E+02	-5.3676E-03	3.6814E-03	2.6858E-03
620	-1.3680E+03	3.5750E+02	3.9045E+02	-1.4682E+02	2.7132E+02	2.0829E+02	-5.4224E-03	3.7281E-03	2.7144E-03
630	-1.3320E+03	3.4875E+02	3.9902E+02	-1.4986E+02	2.7753E+02	2.1289E+02	-5.4767E-03	3.7744E-03	2.7427E-03
640	-1.2960E+03	3.4000E+02	4.0756E+02	-1.5290E+02	2.8373E+02	2.1747E+02	-5.5304E-03	3.8202E-03	2.7707E-03
650	-1.2600E+03	3.3125E+02	4.1607E+02	-1.5593E+02	2.8991E+02	2.2203E+02	-5.5835E-03	3.8656E-03	2.7983E-03
660	-1.2240E+03	3.2250E+02	4.2456E+02	-1.5895E+02	2.9607E+02	2.2658E+02	-5.6361E-03	3.9105E-03	2.8257E-03
670	-1.1880E+03	3.1375E+02	4.3298E+02	-1.6194E+02	3.0219E+02	2.3109E+02	-5.6881E-03	3.9549E-03	2.8526E-03
680	-1.1520E+03	3.0500E+02	4.4112E+02	-1.6484E+02	3.0810E+02	2.3546E+02	-5.7389E-03	3.9983E-03	2.8792E-03
690	-1.1160E+03	2.9625E+02	4.4923E+02	-1.6771E+02	3.1398E+02	2.3981E+02	-5.7892E-03	4.0412E-03	2.9054E-03
700	-1.0800E+03	2.8750E+02	4.5729E+02	-1.7058E+02	3.1984E+02	2.4413E+02	-5.8389E-03	4.0836E-03	2.9312E-03
710	-1.0440E+03	2.7875E+02	4.6532E+02	-1.7343E+02	3.2567E+02	2.4843E+02	-5.8880E-03	4.1256E-03	2.9568E-03
720	-1.0080E+03	2.7000E+02	4.7331E+02	-1.7628E+02	3.3148E+02	2.5271E+02	-5.9366E-03	4.1671E-03	2.9820E-03
730	-9.7200E+02	2.6125E+02	4.8126E+02	-1.7910E+02	3.3725E+02	2.5696E+02	-5.9846E-03	4.2082E-03	3.0069E-03
740	-9.3600E+02	2.5250E+02	4.8844E+02	-1.8164E+02	3.4247E+02	2.6086E+02	-6.0312E-03	4.2476E-03	3.0316E-03
750	-9.0000E+02	2.4375E+02	4.9544E+02	-1.8411E+02	3.4755E+02	2.6467E+02	-6.0770E-03	4.2863E-03	3.0560E-03
760	-8.6400E+02	2.3500E+02	5.0238E+02	-1.8655E+02	3.5258E+02	2.6845E+02	-6.1223E-03	4.3245E-03	3.0801E-03
770	-8.2800E+02	2.2625E+02	5.0925E+02	-1.8897E+02	3.5757E+02	2.7219E+02	-6.1670E-03	4.3623E-03	3.1039E-03
780	-7.9200E+02	2.1750E+02	5.1606E+02	-1.9138E+02	3.6251E+02	2.7589E+02	-6.2110E-03	4.3995E-03	3.1273E-03
790	-7.5600E+02	2.0875E+02	5.2280E+02	-1.9375E+02	3.6740E+02	2.7956E+02	-6.2545E-03	4.4363E-03	3.1504E-03
800	-7.2000E+02	2.0000E+02	5.2942E+02	-1.9609E+02	3.7221E+02	2.8316E+02	-6.2970E-03	4.4722E-03	3.1730E-03
810	-6.8400E+02	1.9125E+02	5.3593E+02	-1.9839E+02	3.7693E+02	2.8670E+02	-6.3386E-03	4.5073E-03	3.1951E-03
820	-6.4800E+02	1.8250E+02	5.4236E+02	-2.0066E+02	3.8160E+02	2.9020E+02	-6.3795E-03	4.5420E-03	3.2168E-03
830	-6.1200E+02	1.7375E+02	5.4873E+02	-2.0290E+02	3.8622E+02	2.9366E+02	-6.4198E-03	4.5761E-03	3.2382E-03
840	-5.7600E+02	1.6500E+02	5.5503E+02	-2.0513E+02	3.9079E+02	2.9708E+02	-6.4596E-03	4.6097E-03	3.2593E-03
850	-5.4000E+02	1.5625E+02	5.6126E+02	-2.0733E+02	3.9531E+02	3.0046E+02	-6.4987E-03	4.6428E-03	3.2800E-03
860	-5.0400E+02	1.4750E+02	5.6741E+02	-2.0950E+02	3.9978E+02	3.0380E+02	-6.5372E-03	4.6754E-03	3.3004E-03
870	-4.6800E+02	1.3875E+02	5.7350E+02	-2.1165E+02	4.0420E+02	3.0710E+02	-6.5751E-03	4.7075E-03	3.3205E-03
880	-4.3200E+02	1.3000E+02	5.7952E+02	-2.1378E+02	4.0857E+02	3.1037E+02	-6.6124E-03	4.7391E-03	3.3403E-03
890	-3.9600E+02	1.2125E+02	5.8546E+02	-2.1588E+02	4.1288E+02	3.1359E+02	-6.6491E-03	4.7702E-03	3.3597E-03
900	-3.6000E+02	1.1250E+02	5.9133E+02	-2.1795E+02	4.1715E+02	3.1677E+02	-6.6852E-03	4.8008E-03	3.3788E-03
910	-3.2400E+02	1.0375E+02	5.9714E+02	-2.2000E+02	4.2136E+02	3.1992E+02	-6.7207E-03	4.8309E-03	3.3976E-03
920	-2.8800E+02	9.5000E+01	6.0287E+02	-2.2203E+02	4.2552E+02	3.2302E+02	-6.7556E-03	4.8604E-03	3.4160E-03
930	-2.5200E+02	8.6250E+01	6.0843E+02	-2.2399E+02	4.2956E+02	3.2604E+02	-6.7892E-03	4.8889E-03	3.4338E-03
940	-2.1600E+02	7.7500E+01	6.1390E+02	-2.2593E+02	4.3353E+02	3.2901E+02	-6.8221E-03	4.9168E-03	3.4512E-03
950	-1.8000E+02	6.8750E+01	6.1930E+02	-2.2783E+02	4.3744E+02	3.3194E+02	-6.8544E-03	4.9441E-03	3.4683E-03
960	-1.4400E+02	6.0000E+01	6.2462E+02	-2.2971E+02	4.4130E+02	3.3482E+02	-6.8860E-03	4.9709E-03	3.4851E-03
970	-1.0800E+02	5.1250E+01	6.2986E+02	-2.3157E+02	4.4510E+02	3.3766E+02	-6.9170E-03	4.9971E-03	3.5015E-03
980	-7.2000E+01	4.2500E+01	6.3503E+02	-2.3339E+02	4.4885E+02	3.4046E+02	-6.9474E-03	5.0229E-03	3.5176E-03
990	-3.6000E+01	3.3750E+01	6.4012E+02	-2.3519E+02	4.5254E+02	3.4322E+02	-6.9772E-03	5.0481E-03	3.5333E-03
1000	.0000E+00	2.5000E+01	6.4513E+02	-2.3697E+02	4.5618E+02	3.4593E+02	-7.0063E-03	5.0728E-03	3.5487E-03
1010	9.0000E+00	3.1250E+01	6.4216E+02	-2.3575E+02	4.5369E+02	3.4535E+02	-6.9904E-03	5.0522E-03	3.5496E-03
1020	1.8000E+01	3.7500E+01	6.3916E+02	-2.3452E+02	4.5117E+02	3.4474E+02	-6.9742E-03	5.0313E-03	3.5504E-03
1030	2.7000E+01	4.3750E+01	6.3612E+02	-2.3328E+02	4.4862E+02	3.4411E+02	-6.9576E-03	5.0101E-03	3.5510E-03
1040	3.6000E+01	5.0000E+01	6.3304E+02	-2.3202E+02	4.4605E+02	3.4345E+02	-6.9408E-03	4.9886E-03	3.5515E-03
1050	4.5000E+01	5.6250E+01	6.2992E+02	-2.3075E+02	4.4344E+02	3.4278E+02	-6.9236E-03	4.9669E-03	3.5518E-03
1060	5.4000E+01	6.2500E+01	6.2677E+02	-2.2947E+02	4.4081E+02	3.4208E+02	-6.9061E-03	4.9449E-03	3.5519E-03
1070	6.3000E+01	6.8750E+01	6.2358E+02	-2.2817E+02	4.3815E+02	3.4136E+02	-6.8884E-03	4.9226E-03	3.5519E-03
1080	7.2000E+01	7.5000E+01	6.2036E+02	-2.2686E+02	4.3546E+02	3.4061E+02	-6.8703E-03	4.9001E-03	3.5517E-03
1090	8.1000E+01	8.1250E+01	6.1709E+02	-2.2554E+02	4.3274E+02	3.3985E+02	-6.8519E-03	4.8773E-03	3.5514E-03

1100	9.0000E+01	8.7500E+01	6.1380E+02	-2.2420E+02	4.2999E+02	3.3906E+02	-6.8332E-03	4.8542E-03	3.5510E-03
1110	9.9000E+01	9.3750E+01	6.1046E+02	-2.2284E+02	4.2721E+02	3.3825E+02	-6.8141E-03	4.8308E-03	3.5503E-03
1120	1.0800E+02	1.0000E+02	6.0701E+02	-2.2145E+02	4.2435E+02	3.3738E+02	-6.7942E-03	4.8067E-03	3.5493E-03
1130	1.1700E+02	1.0625E+02	6.0353E+02	-2.2005E+02	4.2147E+02	3.3649E+02	-6.7740E-03	4.7823E-03	3.5481E-03
1140	1.2600E+02	1.1250E+02	6.0001E+02	-2.1863E+02	4.1855E+02	3.3558E+02	-6.7535E-03	4.7577E-03	3.5468E-03
1150	1.3500E+02	1.1875E+02	5.9646E+02	-2.1720E+02	4.1561E+02	3.3465E+02	-6.7328E-03	4.7328E-03	3.5453E-03
1160	1.4400E+02	1.2500E+02	5.9288E+02	-2.1575E+02	4.1265E+02	3.3370E+02	-6.7117E-03	4.7076E-03	3.5437E-03
1170	1.5300E+02	1.3125E+02	5.8926E+02	-2.1429E+02	4.0965E+02	3.3273E+02	-6.6903E-03	4.6822E-03	3.5419E-03
1180	1.6200E+02	1.3750E+02	5.8561E+02	-2.1282E+02	4.0663E+02	3.3173E+02	-6.6686E-03	4.6565E-03	3.5400E-03
1190	1.7100E+02	1.4375E+02	5.8193E+02	-2.1134E+02	4.0359E+02	3.3072E+02	-6.6466E-03	4.6306E-03	3.5379E-03
1200	1.8000E+02	1.5000E+02	5.7821E+02	-2.0985E+02	4.0051E+02	3.2968E+02	-6.6243E-03	4.6044E-03	3.5357E-03
1210	1.8900E+02	1.7500E+02	5.6635E+02	-2.0398E+02	3.8847E+02	3.3203E+02	-6.5567E-03	4.4814E-03	3.5857E-03
1220	1.9800E+02	2.0000E+02	5.5414E+02	-1.9792E+02	3.7601E+02	3.3404E+02	-6.4843E-03	4.3541E-03	3.6336E-03
1230	2.0700E+02	2.2500E+02	5.4138E+02	-1.9158E+02	3.6297E+02	3.3559E+02	-6.4056E-03	4.2211E-03	3.6785E-03
1240	2.1600E+02	2.5000E+02	5.2830E+02	-1.8504E+02	3.4952E+02	3.3678E+02	-6.3220E-03	4.0837E-03	3.7213E-03
1250	2.2500E+02	2.7500E+02	5.1354E+02	-1.7777E+02	3.3464E+02	3.3689E+02	-6.2324E-03	3.9395E-03	3.7629E-03
1260	2.3400E+02	3.0000E+02	4.9775E+02	-1.7002E+02	3.1881E+02	3.3619E+02	-6.1376E-03	3.7897E-03	3.8035E-03
1270	2.4300E+02	3.2500E+02	4.8164E+02	-1.6204E+02	3.0253E+02	3.3502E+02	-6.0380E-03	3.6351E-03	3.8424E-03
1280	2.5200E+02	3.5000E+02	4.6512E+02	-1.5379E+02	2.8571E+02	3.3330E+02	-5.9332E-03	3.4753E-03	3.8797E-03
1290	2.6100E+02	3.7500E+02	4.4845E+02	-1.4535E+02	2.6852E+02	3.3112E+02	-5.8244E-03	3.3113E-03	3.9161E-03
1300	2.7000E+02	4.0000E+02	4.3157E+02	-1.3668E+02	2.5090E+02	3.2838E+02	-5.7117E-03	3.1428E-03	3.9518E-03
1310	2.7900E+02	4.2500E+02	4.1485E+02	-1.2791E+02	2.3309E+02	3.2528E+02	-5.5948E-03	2.9700E-03	3.9862E-03
1320	2.8800E+02	4.5000E+02	3.9831E+02	-1.1903E+02	2.1506E+02	3.2176E+02	-5.4736E-03	2.7927E-03	4.0195E-03
1330	2.9700E+02	4.7500E+02	3.8213E+02	-1.1009E+02	1.9692E+02	3.1787E+02	-5.3485E-03	2.6113E-03	4.0518E-03
1340	3.0600E+02	5.0000E+02	3.6337E+02	-1.0074E+02	1.7689E+02	3.1052E+02	-5.2354E-03	2.4249E-03	4.0854E-03
1350	3.1500E+02	5.2500E+02	3.4423E+02	-9.0282E+01	1.5668E+02	3.0292E+02	-5.1326E-03	2.2319E-03	4.1383E-03
1360	3.2400E+02	5.5000E+02	3.2590E+02	-8.0031E+01	1.3671E+02	2.9475E+02	-5.0262E-03	2.0343E-03	4.1900E-03
1370	3.3300E+02	5.7500E+02	3.0820E+02	-6.9981E+01	1.1696E+02	2.8575E+02	-4.9186E-03	1.8325E-03	4.2413E-03
1380	3.4200E+02	6.0000E+02	2.8583E+02	-5.9053E+01	9.5861E+01	2.7079E+02	-4.8524E-03	1.6214E-03	4.3198E-03
1390	3.5100E+02	6.2500E+02	2.5264E+02	-4.6414E+01	7.2809E+01	2.4377E+02	-4.8819E-03	1.3916E-03	4.4671E-03
1400	3.6000E+02	6.5000E+02	2.1140E+02	-3.2327E+01	5.0879E+01	2.0801E+02	-5.0190E-03	1.1338E-03	4.7223E-03
1410	3.6900E+02	6.2500E+02	2.0797E+02	-3.9462E+01	6.5506E+01	2.0007E+02	-5.2615E-03	1.3338E-03	4.7452E-03
1420	3.7800E+02	6.0000E+02	2.1435E+02	-4.7393E+01	8.1521E+01	2.0004E+02	-5.4461E-03	1.5363E-03	4.7387E-03
1430	3.8700E+02	5.7500E+02	2.2678E+02	-5.6040E+01	9.9081E+01	2.0423E+02	-5.5947E-03	1.7372E-03	4.7160E-03
1440	3.9600E+02	5.5000E+02	2.4098E+02	-6.4803E+01	1.1696E+02	2.0854E+02	-5.7373E-03	1.9343E-03	4.6917E-03
1450	4.0500E+02	5.2500E+02	2.5637E+02	-7.3622E+01	1.3498E+02	2.1259E+02	-5.8763E-03	2.1276E-03	4.6667E-03
1460	4.1400E+02	5.0000E+02	2.7267E+02	-8.2443E+01	1.5301E+02	2.1630E+02	-6.0113E-03	2.3166E-03	4.6406E-03
1470	4.2300E+02	4.7500E+02	2.8973E+02	-9.1261E+01	1.7106E+02	2.1971E+02	-6.1430E-03	2.5020E-03	4.6139E-03
1480	4.3200E+02	4.5000E+02	3.0716E+02	-9.9974E+01	1.8890E+02	2.2268E+02	-6.2701E-03	2.6827E-03	4.5859E-03
1490	4.4100E+02	4.2500E+02	3.2502E+02	-1.0863E+02	2.0665E+02	2.2532E+02	-6.3932E-03	2.8592E-03	4.5566E-03
1500	4.5000E+02	4.0000E+02	3.4309E+02	-1.1719E+02	2.2419E+02	2.2759E+02	-6.5119E-03	3.0314E-03	4.5259E-03
1510	4.5900E+02	3.7500E+02	3.6134E+02	-1.2565E+02	2.4155E+02	2.2952E+02	-6.6263E-03	3.1993E-03	4.4938E-03
1520	4.6800E+02	3.5000E+02	3.7940E+02	-1.3391E+02	2.5851E+02	2.3097E+02	-6.7365E-03	3.3628E-03	4.4605E-03
1530	4.7700E+02	3.2500E+02	3.9731E+02	-1.4199E+02	2.7511E+02	2.3202E+02	-6.8426E-03	3.5221E-03	4.4259E-03
1540	4.8600E+02	3.0000E+02	4.1482E+02	-1.4982E+02	2.9119E+02	2.3256E+02	-6.9434E-03	3.6763E-03	4.3894E-03
1550	4.9500E+02	2.7500E+02	4.3197E+02	-1.5742E+02	3.0683E+02	2.3266E+02	-7.0392E-03	3.8257E-03	4.3510E-03
1560	5.0400E+02	2.5000E+02	4.4813E+02	-1.6457E+02	3.2156E+02	2.3206E+02	-7.1295E-03	3.9695E-03	4.3109E-03
1570	5.1300E+02	2.2500E+02	4.6268E+02	-1.7104E+02	3.3491E+02	2.3052E+02	-7.2134E-03	4.1069E-03	4.2688E-03
1580	5.2200E+02	2.0000E+02	4.7686E+02	-1.7730E+02	3.4785E+02	2.2863E+02	-7.2924E-03	4.2397E-03	4.2244E-03
1590	5.3100E+02	1.7500E+02	4.9045E+02	-1.8329E+02	3.6021E+02	2.2628E+02	-7.3650E-03	4.3669E-03	4.1771E-03
1600	5.4000E+02	1.5000E+02	5.0367E+02	-1.8908E+02	3.7216E+02	2.2359E+02	-7.4329E-03	4.4898E-03	4.1277E-03
1610	5.4900E+02	1.7500E+02	4.9045E+02	-1.8329E+02	3.6021E+02	2.2628E+02	-7.3650E-03	4.3669E-03	4.1771E-03
1620	5.5800E+02	2.0000E+02	4.7686E+02	-1.7730E+02	3.4785E+02	2.2863E+02	-7.2924E-03	4.2397E-03	4.2244E-03
1630	5.6700E+02	2.2500E+02	4.6268E+02	-1.7104E+02	3.3491E+02	2.3052E+02	-7.2134E-03	4.1069E-03	4.2688E-03
1640	5.7600E+02	2.5000E+02	4.4813E+02	-1.6457E+02	3.2156E+02	2.3206E+02	-7.1295E-03	3.9695E-03	4.3109E-03
1650	5.8500E+02	2.7500E+02	4.3197E+02	-1.5742E+02	3.0683E+02	2.3266E+02	-7.0392E-03	3.8257E-03	4.3510E-03
1660	5.9400E+02	3.0000E+02	4.1482E+02	-1.4982E+02	2.9119E+02	2.3256E+02	-6.9434E-03	3.6763E-03	4.3894E-03
1670	6.0300E+02	3.2500E+02	3.9731E+02	-1.4199E+02	2.7511E+02	2.3202E+02	-6.8426E-03	3.5221E-03	4.4259E-03
1680	6.1200E+02	3.5000E+02	3.7940E+02	-1.3391E+02	2.5851E+02	2.3097E+02	-6.7365E-03	3.3628E-03	4.4605E-03
1690	6.2100E+02	3.7500E+02	3.6134E+02	-1.2565E+02	2.4155E+02	2.2952E+02	-6.6263E-03	3.1993E-03	4.4938E-03
1700	6.3000E+02	4.0000E+02	3.4309E+02	-1.1719E+02	2.2419E+02	2.2759E+02	-6.5119E-03	3.0314E-03	4.5259E-03

1710	6.3900E+02	4.2500E+02	3.2502E+02	-1.0863E+02	2.0665E+02	2.2532E+02	-6.3932E-03	2.8592E-03	4.5566E-03
1720	6.4800E+02	4.5000E+02	3.0716E+02	-9.9974E+01	1.8890E+02	2.2268E+02	-6.2701E-03	2.6827E-03	4.5859E-03
1730	6.5700E+02	4.7500E+02	2.8973E+02	-9.1261E+01	1.7106E+02	2.1971E+02	-6.1430E-03	2.5020E-03	4.6139E-03
1740	6.6600E+02	5.0000E+02	2.7267E+02	-8.2443E+01	1.5301E+02	2.1630E+02	-6.0113E-03	2.3166E-03	4.6406E-03
1750	6.7500E+02	5.2500E+02	2.5637E+02	-7.3622E+01	1.3498E+02	2.1259E+02	-5.8763E-03	2.1276E-03	4.6667E-03
1760	6.8400E+02	5.5000E+02	2.4098E+02	-6.4803E+01	1.1696E+02	2.0854E+02	-5.7373E-03	1.9343E-03	4.6917E-03
1770	6.9300E+02	5.7500E+02	2.2601E+02	-5.5997E+01	9.8682E+01	2.0337E+02	-5.5992E-03	1.7372E-03	4.7163E-03
1780	7.0200E+02	6.0000E+02	2.0892E+02	-4.6390E+01	7.9283E+01	1.9477E+02	-5.4850E-03	1.5333E-03	4.7576E-03
1790	7.1100E+02	6.2500E+02	1.9266E+02	-3.6878E+01	6.0287E+01	1.8501E+02	-5.3739E-03	1.3234E-03	4.8041E-03
1800	7.2000E+02	6.5000E+02	1.7425E+02	-2.7236E+01	4.1501E+01	1.7090E+02	-5.2938E-03	1.1047E-03	4.8733E-03
1810	7.2900E+02	6.2500E+02	1.7822E+02	-3.4960E+01	5.7540E+01	1.7049E+02	-5.4865E-03	1.3087E-03	4.8758E-03
1820	7.3800E+02	6.0000E+02	1.8734E+02	-4.3210E+01	7.4241E+01	1.7283E+02	-5.6521E-03	1.5128E-03	4.8610E-03
1830	7.4700E+02	5.7500E+02	2.0024E+02	-5.1815E+01	9.1791E+01	1.7693E+02	-5.7996E-03	1.7135E-03	4.8392E-03
1840	7.5600E+02	5.5000E+02	2.1480E+02	-6.0509E+01	1.0956E+02	1.8088E+02	-5.9428E-03	1.9103E-03	4.8162E-03
1850	7.6500E+02	5.2500E+02	2.3064E+02	-6.9263E+01	1.2747E+02	1.8457E+02	-6.0824E-03	2.1034E-03	4.7925E-03
1860	7.7400E+02	5.0000E+02	2.4745E+02	-7.8021E+01	1.4540E+02	1.8794E+02	-6.2179E-03	2.2922E-03	4.7676E-03
1870	7.8300E+02	4.7500E+02	2.6505E+02	-8.6780E+01	1.6334E+02	1.9103E+02	-6.3501E-03	2.4774E-03	4.7419E-03
1880	7.9200E+02	4.5000E+02	2.8305E+02	-9.5438E+01	1.8110E+02	1.9370E+02	-6.4777E-03	2.6579E-03	4.7149E-03
1890	8.0100E+02	4.2500E+02	3.0146E+02	-1.0404E+02	1.9875E+02	1.9606E+02	-6.6012E-03	2.8343E-03	4.6865E-03
1900	8.1000E+02	4.0000E+02	3.2007E+02	-1.1255E+02	2.1621E+02	1.9806E+02	-6.7203E-03	3.0063E-03	4.6567E-03
1910	8.1900E+02	3.7500E+02	3.3884E+02	-1.2097E+02	2.3349E+02	1.9973E+02	-6.8351E-03	3.1741E-03	4.6253E-03
1920	8.2800E+02	3.5000E+02	3.5742E+02	-1.2918E+02	2.5038E+02	2.0095E+02	-6.9456E-03	3.3375E-03	4.5928E-03
1930	8.3700E+02	3.2500E+02	3.7582E+02	-1.3722E+02	2.6691E+02	2.0177E+02	-7.0520E-03	3.4967E-03	4.5588E-03
1940	8.4600E+02	3.0000E+02	3.9380E+02	-1.4501E+02	2.8293E+02	2.0211E+02	-7.1531E-03	3.6508E-03	4.5229E-03
1950	8.5500E+02	2.7500E+02	4.1142E+02	-1.5258E+02	2.9851E+02	2.0202E+02	-7.2491E-03	3.8001E-03	4.4850E-03
1960	8.6400E+02	2.5000E+02	4.2805E+02	-1.5970E+02	3.1319E+02	2.0126E+02	-7.3396E-03	3.9439E-03	4.4452E-03
1970	8.7300E+02	2.2500E+02	4.4307E+02	-1.6615E+02	3.2652E+02	1.9962E+02	-7.4236E-03	4.0812E-03	4.4032E-03
1980	8.8200E+02	2.0000E+02	4.5770E+02	-1.7240E+02	3.3942E+02	1.9763E+02	-7.5026E-03	4.2140E-03	4.3590E-03
1990	8.9100E+02	1.7500E+02	4.7174E+02	-1.7837E+02	3.5175E+02	1.9517E+02	-7.5753E-03	4.3412E-03	4.3118E-03
2000	9.0000E+02	1.5000E+02	4.8539E+02	-1.8414E+02	3.6367E+02	1.9238E+02	-7.6433E-03	4.4640E-03	4.2626E-03
2010	9.0900E+02	1.7500E+02	4.7174E+02	-1.7837E+02	3.5175E+02	1.9517E+02	-7.5753E-03	4.3412E-03	4.3118E-03
2020	9.1800E+02	2.0000E+02	4.5770E+02	-1.7240E+02	3.3942E+02	1.9763E+02	-7.5026E-03	4.2140E-03	4.3590E-03
2030	9.2700E+02	2.2500E+02	4.4307E+02	-1.6615E+02	3.2652E+02	1.9962E+02	-7.4236E-03	4.0812E-03	4.4032E-03
2040	9.3600E+02	2.5000E+02	4.2805E+02	-1.5970E+02	3.1319E+02	2.0126E+02	-7.3396E-03	3.9439E-03	4.4452E-03
2050	9.4500E+02	2.7500E+02	4.1142E+02	-1.5258E+02	2.9851E+02	2.0202E+02	-7.2491E-03	3.8001E-03	4.4850E-03
2060	9.5400E+02	3.0000E+02	3.9380E+02	-1.4501E+02	2.8293E+02	2.0211E+02	-7.1531E-03	3.6508E-03	4.5229E-03
2070	9.6300E+02	3.2500E+02	3.7582E+02	-1.3722E+02	2.6691E+02	2.0177E+02	-7.0520E-03	3.4967E-03	4.5588E-03
2080	9.7200E+02	3.5000E+02	3.5742E+02	-1.2918E+02	2.5038E+02	2.0095E+02	-6.9456E-03	3.3375E-03	4.5928E-03
2090	9.8100E+02	3.7500E+02	3.3884E+02	-1.2097E+02	2.3349E+02	1.9973E+02	-6.8351E-03	3.1741E-03	4.6253E-03
2100	9.9000E+02	4.0000E+02	3.2007E+02	-1.1255E+02	2.1621E+02	1.9806E+02	-6.7203E-03	3.0063E-03	4.6567E-03
2110	9.9900E+02	4.2500E+02	3.0146E+02	-1.0404E+02	1.9875E+02	1.9606E+02	-6.6012E-03	2.8343E-03	4.6865E-03
2120	1.0080E+03	4.5000E+02	2.8305E+02	-9.5438E+01	1.8110E+02	1.9370E+02	-6.4777E-03	2.6579E-03	4.7149E-03
2130	1.0170E+03	4.7500E+02	2.6505E+02	-8.6780E+01	1.6334E+02	1.9103E+02	-6.3501E-03	2.4774E-03	4.7419E-03
2140	1.0260E+03	5.0000E+02	2.4745E+02	-7.8021E+01	1.4540E+02	1.8794E+02	-6.2179E-03	2.2922E-03	4.7676E-03
2150	1.0350E+03	5.2500E+02	2.3064E+02	-6.9263E+01	1.2747E+02	1.8457E+02	-6.0824E-03	2.1034E-03	4.7925E-03
2160	1.0440E+03	5.5000E+02	2.1480E+02	-6.0509E+01	1.0956E+02	1.8088E+02	-5.9428E-03	1.9103E-03	4.8162E-03
2170	1.0530E+03	5.7500E+02	2.0021E+02	-5.1814E+01	9.1773E+01	1.7689E+02	-5.7998E-03	1.7135E-03	4.8392E-03
2180	1.0620E+03	6.0000E+02	1.8432E+02	-4.2662E+01	7.2951E+01	1.6990E+02	-5.6733E-03	1.5113E-03	4.8707E-03
2190	1.0710E+03	6.2500E+02	1.7037E+02	-3.3533E+01	5.4698E+01	1.6285E+02	-5.5450E-03	1.3033E-03	4.9070E-03
2200	1.0800E+03	6.5000E+02	1.5618E+02	-2.4414E+01	3.6728E+01	1.5308E+02	-5.4346E-03	1.0885E-03	4.9572E-03
2210	1.0890E+03	6.2500E+02	1.6237E+02	-3.2392E+01	5.3169E+01	1.5486E+02	-5.6094E-03	1.2945E-03	4.9500E-03
2220	1.0980E+03	6.0000E+02	1.7248E+02	-4.0746E+01	7.0108E+01	1.5797E+02	-5.7685E-03	1.4990E-03	4.9326E-03
2230	1.1070E+03	5.7500E+02	1.8559E+02	-4.9315E+01	8.7613E+01	1.6191E+02	-5.9160E-03	1.6996E-03	4.9115E-03
2240	1.1160E+03	5.5000E+02	2.0039E+02	-5.7969E+01	1.0532E+02	1.6566E+02	-6.0595E-03	1.8963E-03	4.8893E-03
2250	1.1250E+03	5.2500E+02	2.1654E+02	-6.6683E+01	1.2316E+02	1.6916E+02	-6.1995E-03	2.0892E-03	4.8663E-03
2260	1.1340E+03	5.0000E+02	2.3368E+02	-7.5404E+01	1.4103E+02	1.7235E+02	-6.3354E-03	2.2780E-03	4.8421E-03
2270	1.1430E+03	4.7500E+02	2.5162E+02	-8.4128E+01	1.5892E+02	1.7527E+02	-6.4679E-03	2.4631E-03	4.8171E-03
2280	1.1520E+03	4.5000E+02	2.6996E+02	-9.2753E+01	1.7662E+02	1.7778E+02	-6.5957E-03	2.6434E-03	4.7906E-03
2290	1.1610E+03	4.2500E+02	2.8870E+02	-1.0133E+02	1.9423E+02	1.7999E+02	-6.7195E-03	2.8198E-03	4.7628E-03
2300	1.1700E+03	4.0000E+02	3.0763E+02	-1.0980E+02	2.1164E+02	1.8184E+02	-6.8388E-03	2.9917E-03	4.7335E-03
2310	1.1790E+03	3.7500E+02	3.2670E+02	-1.1819E+02	2.2887E+02	1.8337E+02	-6.9538E-03	3.1593E-03	4.7026E-03

2320	1.1880E+03	3.5000E+02	3.4557E+02	-1.2638E+02	2.4572E+02	1.8447E+02	-7.0646E-03	3.3227E-03	4.6704E-03
2330	1.1970E+03	3.2500E+02	3.6425E+02	-1.3440E+02	2.6221E+02	1.8517E+02	-7.1711E-03	3.4818E-03	4.6368E-03
2340	1.2060E+03	3.0000E+02	3.8250E+02	-1.4217E+02	2.7820E+02	1.8540E+02	-7.2723E-03	3.6358E-03	4.6012E-03
2350	1.2150E+03	2.7500E+02	4.0038E+02	-1.4972E+02	2.9374E+02	1.8521E+02	-7.3685E-03	3.7851E-03	4.5636E-03
2360	1.2240E+03	2.5000E+02	4.1726E+02	-1.5682E+02	3.0839E+02	1.8437E+02	-7.4591E-03	3.9289E-03	4.5241E-03
2370	1.2330E+03	2.2500E+02	4.3254E+02	-1.6326E+02	3.2170E+02	1.8267E+02	-7.5431E-03	4.0662E-03	4.4822E-03
2380	1.2420E+03	2.0000E+02	4.4743E+02	-1.6949E+02	3.3459E+02	1.8062E+02	-7.6222E-03	4.1990E-03	4.4380E-03
2390	1.2510E+03	1.7500E+02	4.6171E+02	-1.7545E+02	3.4690E+02	1.7811E+02	-7.6949E-03	4.3261E-03	4.3909E-03
2400	1.2600E+03	1.5000E+02	4.7559E+02	-1.8121E+02	3.5880E+02	1.7525E+02	-7.7629E-03	4.4490E-03	4.3417E-03
2410	1.2690E+03	1.7500E+02	4.6171E+02	-1.7545E+02	3.4690E+02	1.7811E+02	-7.6949E-03	4.3261E-03	4.3909E-03
2420	1.2780E+03	2.0000E+02	4.4743E+02	-1.6949E+02	3.3459E+02	1.8062E+02	-7.6222E-03	4.1990E-03	4.4380E-03
2430	1.2870E+03	2.2500E+02	4.3254E+02	-1.6326E+02	3.2170E+02	1.8267E+02	-7.5431E-03	4.0662E-03	4.4822E-03
2440	1.2960E+03	2.5000E+02	4.1726E+02	-1.5682E+02	3.0839E+02	1.8437E+02	-7.4591E-03	3.9289E-03	4.5241E-03
2450	1.3050E+03	2.7500E+02	4.0038E+02	-1.4972E+02	2.9374E+02	1.8521E+02	-7.3685E-03	3.7851E-03	4.5636E-03
2460	1.3140E+03	3.0000E+02	3.8250E+02	-1.4217E+02	2.7820E+02	1.8540E+02	-7.2723E-03	3.6358E-03	4.6012E-03
2470	1.3230E+03	3.2500E+02	3.6425E+02	-1.3440E+02	2.6221E+02	1.8517E+02	-7.1711E-03	3.4818E-03	4.6368E-03
2480	1.3320E+03	3.5000E+02	3.4557E+02	-1.2638E+02	2.4572E+02	1.8447E+02	-7.0646E-03	3.3227E-03	4.6704E-03
2490	1.3410E+03	3.7500E+02	3.2670E+02	-1.1819E+02	2.2887E+02	1.8337E+02	-6.9538E-03	3.1593E-03	4.7026E-03
2500	1.3500E+03	4.0000E+02	3.0763E+02	-1.0980E+02	2.1164E+02	1.8184E+02	-6.8388E-03	2.9917E-03	4.7335E-03
2510	1.3590E+03	4.2500E+02	2.8870E+02	-1.0133E+02	1.9423E+02	1.7999E+02	-6.7195E-03	2.8198E-03	4.7628E-03
2520	1.3680E+03	4.5000E+02	2.6996E+02	-9.2753E+01	1.7662E+02	1.7778E+02	-6.5957E-03	2.6434E-03	4.7906E-03
2530	1.3770E+03	4.7500E+02	2.5162E+02	-8.4128E+01	1.5892E+02	1.7527E+02	-6.4679E-03	2.4631E-03	4.8171E-03
2540	1.3860E+03	5.0000E+02	2.3368E+02	-7.5404E+01	1.4103E+02	1.7235E+02	-6.3354E-03	2.2780E-03	4.8421E-03
2550	1.3950E+03	5.2500E+02	2.1654E+02	-6.6683E+01	1.2316E+02	1.6916E+02	-6.1995E-03	2.0892E-03	4.8663E-03
2560	1.4040E+03	5.5000E+02	2.0039E+02	-5.7969E+01	1.0532E+02	1.6566E+02	-6.0595E-03	1.8963E-03	4.8893E-03
2570	1.4130E+03	5.7500E+02	1.8559E+02	-4.9315E+01	8.7612E+01	1.6191E+02	-5.9160E-03	1.6996E-03	4.9115E-03
2580	1.4220E+03	6.0000E+02	1.7049E+02	-4.0438E+01	6.9234E+01	1.5597E+02	-5.7817E-03	1.4983E-03	4.9374E-03
2590	1.4310E+03	6.2500E+02	1.5739E+02	-3.1479E+01	5.1303E+01	1.5003E+02	-5.6465E-03	1.2912E-03	4.9694E-03
2600	1.4400E+03	6.5000E+02	1.4507E+02	-2.2610E+01	3.3711E+01	1.4218E+02	-5.5226E-03	1.0781E-03	5.0108E-03
2610	1.4490E+03	6.2500E+02	1.5218E+02	-3.0693E+01	5.0316E+01	1.4486E+02	-5.6897E-03	1.2850E-03	4.9994E-03
2620	1.4580E+03	6.0000E+02	1.6278E+02	-3.9086E+01	6.7364E+01	1.4830E+02	-5.8457E-03	1.4897E-03	4.9811E-03
2630	1.4670E+03	5.7500E+02	1.7604E+02	-4.7628E+01	8.4833E+01	1.5213E+02	-5.9934E-03	1.6902E-03	4.9605E-03
2640	1.4760E+03	5.5000E+02	1.9103E+02	-5.6254E+01	1.0249E+02	1.5575E+02	-6.1372E-03	1.8868E-03	4.9389E-03
2650	1.4850E+03	5.2500E+02	2.0740E+02	-6.4942E+01	1.2030E+02	1.5912E+02	-6.2773E-03	2.0796E-03	4.9164E-03
2660	1.4940E+03	5.0000E+02	2.2477E+02	-7.3638E+01	1.3813E+02	1.6220E+02	-6.4134E-03	2.2683E-03	4.8926E-03
2670	1.5030E+03	4.7500E+02	2.4296E+02	-8.2338E+01	1.5598E+02	1.6501E+02	-6.5462E-03	2.4533E-03	4.8681E-03
2680	1.5120E+03	4.5000E+02	2.6153E+02	-9.0942E+01	1.7364E+02	1.6742E+02	-6.6742E-03	2.6336E-03	4.8420E-03
2690	1.5210E+03	4.2500E+02	2.8050E+02	-9.9495E+01	1.9122E+02	1.6953E+02	-6.7981E-03	2.8098E-03	4.8146E-03
2700	1.5300E+03	4.0000E+02	2.9964E+02	-1.0795E+02	2.0860E+02	1.7129E+02	-6.9176E-03	2.9817E-03	4.7856E-03
2710	1.5390E+03	3.7500E+02	3.1892E+02	-1.1632E+02	2.2580E+02	1.7273E+02	-7.0328E-03	3.1493E-03	4.7550E-03
2720	1.5480E+03	3.5000E+02	3.3798E+02	-1.2449E+02	2.4261E+02	1.7374E+02	-7.1436E-03	3.3126E-03	4.7231E-03
2730	1.5570E+03	3.2500E+02	3.5684E+02	-1.3249E+02	2.5908E+02	1.7437E+02	-7.2503E-03	3.4717E-03	4.6898E-03
2740	1.5660E+03	3.0000E+02	3.7527E+02	-1.4025E+02	2.7505E+02	1.7453E+02	-7.3516E-03	3.6257E-03	4.6544E-03
2750	1.5750E+03	2.7500E+02	3.9332E+02	-1.4778E+02	2.9057E+02	1.7428E+02	-7.4479E-03	3.7749E-03	4.6170E-03
2760	1.5840E+03	2.5000E+02	4.1036E+02	-1.5487E+02	3.0520E+02	1.7338E+02	-7.5386E-03	3.9186E-03	4.5776E-03
2770	1.5930E+03	2.2500E+02	4.2581E+02	-1.6131E+02	3.1850E+02	1.7164E+02	-7.6226E-03	4.0559E-03	4.5357E-03
2780	1.6020E+03	2.0000E+02	4.4087E+02	-1.6753E+02	3.3138E+02	1.6956E+02	-7.7017E-03	4.1888E-03	4.4916E-03
2790	1.6110E+03	1.7500E+02	4.5530E+02	-1.7349E+02	3.4368E+02	1.6701E+02	-7.7745E-03	4.3159E-03	4.4446E-03
2800	1.6200E+03	1.5000E+02	4.6934E+02	-1.7924E+02	3.5557E+02	1.6412E+02	-7.8425E-03	4.4387E-03	4.3954E-03
2810	1.6290E+03	1.7500E+02	4.5530E+02	-1.7349E+02	3.4368E+02	1.6701E+02	-7.7745E-03	4.3159E-03	4.4446E-03
2820	1.6380E+03	2.0000E+02	4.4087E+02	-1.6753E+02	3.3138E+02	1.6956E+02	-7.7017E-03	4.1888E-03	4.4916E-03
2830	1.6470E+03	2.2500E+02	4.2581E+02	-1.6131E+02	3.1850E+02	1.7164E+02	-7.6226E-03	4.0559E-03	4.5357E-03
2840	1.6560E+03	2.5000E+02	4.1036E+02	-1.5487E+02	3.0520E+02	1.7338E+02	-7.5386E-03	3.9186E-03	4.5776E-03
2850	1.6650E+03	2.7500E+02	3.9332E+02	-1.4778E+02	2.9057E+02	1.7428E+02	-7.4479E-03	3.7749E-03	4.6170E-03
2860	1.6740E+03	3.0000E+02	3.7527E+02	-1.4025E+02	2.7505E+02	1.7453E+02	-7.3516E-03	3.6257E-03	4.6544E-03
2870	1.6830E+03	3.2500E+02	3.5684E+02	-1.3249E+02	2.5908E+02	1.7437E+02	-7.2503E-03	3.4717E-03	4.6898E-03
2880	1.6920E+03	3.5000E+02	3.3798E+02	-1.2449E+02	2.4261E+02	1.7374E+02	-7.1436E-03	3.3126E-03	4.7231E-03
2890	1.7010E+03	3.7500E+02	3.1892E+02	-1.1632E+02	2.2580E+02	1.7273E+02	-7.0328E-03	3.1493E-03	4.7550E-03
2900	1.7100E+03	4.0000E+02	2.9964E+02	-1.0795E+02	2.0860E+02	1.7129E+02	-6.9176E-03	2.9817E-03	4.7856E-03
2910	1.7190E+03	4.2500E+02	2.8050E+02	-9.9495E+01	1.9122E+02	1.6953E+02	-6.7981E-03	2.8098E-03	4.8146E-03
2920	1.7280E+03	4.5000E+02	2.6153E+02	-9.0942E+01	1.7364E+02	1.6742E+02	-6.6742E-03	2.6336E-03	4.8420E-03

2930	1.7370E+03	4.7500E+02	2.4296E+02	-8.2338E+01	1.5598E+02	1.6501E+02	-6.5462E-03	2.4533E-03	4.8681E-03
2940	1.7460E+03	5.0000E+02	2.2477E+02	-7.3638E+01	1.3813E+02	1.6220E+02	-6.4134E-03	2.2683E-03	4.8926E-03
2950	1.7550E+03	5.2500E+02	2.0740E+02	-6.4942E+01	1.2030E+02	1.5912E+02	-6.2773E-03	2.0796E-03	4.9164E-03
2960	1.7640E+03	5.5000E+02	1.9103E+02	-5.6254E+01	1.0249E+02	1.5575E+02	-6.1372E-03	1.8868E-03	4.9389E-03
2970	1.7730E+03	5.7500E+02	1.7604E+02	-4.7628E+01	8.4833E+01	1.5213E+02	-5.9934E-03	1.6902E-03	4.9605E-03
2980	1.7820E+03	6.0000E+02	1.6141E+02	-3.8927E+01	6.6746E+01	1.4687E+02	-5.8542E-03	1.4894E-03	4.9831E-03
2990	1.7910E+03	6.2500E+02	1.4870E+02	-3.0072E+01	4.8977E+01	1.4146E+02	-5.7153E-03	1.2828E-03	5.0123E-03
3000	1.8000E+03	6.5000E+02	1.3742E+02	-2.1348E+01	3.1602E+01	1.3466E+02	-5.5840E-03	1.0708E-03	5.0486E-03
3010	1.8090E+03	6.2500E+02	1.4496E+02	-2.9477E+01	4.8281E+01	1.3778E+02	-5.7472E-03	1.2781E-03	5.0353E-03
3020	1.8180E+03	6.0000E+02	1.5585E+02	-3.7881E+01	6.5387E+01	1.4138E+02	-5.9017E-03	1.4828E-03	5.0168E-03
3030	1.8270E+03	5.7500E+02	1.6921E+02	-4.6403E+01	8.2827E+01	1.4513E+02	-6.0496E-03	1.6832E-03	4.9967E-03
3040	1.8360E+03	5.5000E+02	1.8435E+02	-5.5009E+01	1.0046E+02	1.4866E+02	-6.1935E-03	1.8797E-03	4.9755E-03
3050	1.8450E+03	5.2500E+02	2.0090E+02	-6.3678E+01	1.1823E+02	1.5195E+02	-6.3339E-03	2.0725E-03	4.9533E-03
3060	1.8540E+03	5.0000E+02	2.1846E+02	-7.2357E+01	1.3603E+02	1.5494E+02	-6.4701E-03	2.2611E-03	4.9299E-03
3070	1.8630E+03	4.7500E+02	2.3683E+02	-8.1040E+01	1.5385E+02	1.5767E+02	-6.6030E-03	2.4461E-03	4.9056E-03
3080	1.8720E+03	4.5000E+02	2.5557E+02	-8.9627E+01	1.7150E+02	1.6001E+02	-6.7312E-03	2.6263E-03	4.8798E-03
3090	1.8810E+03	4.2500E+02	2.7471E+02	-9.8166E+01	1.8904E+02	1.6205E+02	-6.8552E-03	2.8025E-03	4.8527E-03
3100	1.8900E+03	4.0000E+02	2.9401E+02	-1.0661E+02	2.0640E+02	1.6375E+02	-6.9749E-03	2.9743E-03	4.8239E-03
3110	1.8990E+03	3.7500E+02	3.1343E+02	-1.1496E+02	2.2358E+02	1.6512E+02	-7.0901E-03	3.1419E-03	4.7936E-03
3120	1.9080E+03	3.5000E+02	3.3263E+02	-1.2312E+02	2.4038E+02	1.6608E+02	-7.2011E-03	3.3051E-03	4.7619E-03
3130	1.9170E+03	3.2500E+02	3.5163E+02	-1.3111E+02	2.5683E+02	1.6666E+02	-7.3078E-03	3.4642E-03	4.7288E-03
3140	1.9260E+03	3.0000E+02	3.7019E+02	-1.3885E+02	2.7277E+02	1.6677E+02	-7.4092E-03	3.6182E-03	4.6935E-03
3150	1.9350E+03	2.7500E+02	3.8835E+02	-1.4638E+02	2.8828E+02	1.6646E+02	-7.5056E-03	3.7674E-03	4.6563E-03
3160	1.9440E+03	2.5000E+02	4.0552E+02	-1.5346E+02	3.0290E+02	1.6553E+02	-7.5963E-03	3.9111E-03	4.6170E-03
3170	1.9530E+03	2.2500E+02	4.2109E+02	-1.5989E+02	3.1619E+02	1.6376E+02	-7.6803E-03	4.0484E-03	4.5751E-03
3180	1.9620E+03	2.0000E+02	4.3626E+02	-1.6611E+02	3.2906E+02	1.6165E+02	-7.7595E-03	4.1812E-03	4.5311E-03
3190	1.9710E+03	1.7500E+02	4.5081E+02	-1.7206E+02	3.4135E+02	1.5908E+02	-7.8322E-03	4.3083E-03	4.4841E-03
3200	1.9800E+03	1.5000E+02	4.6496E+02	-1.7781E+02	3.5323E+02	1.5616E+02	-7.9003E-03	4.4311E-03	4.4350E-03

Cross-Sectional Results at Step 3200
time = 1980.0000

Radius	Seff	Srad	Stan	Sz	Er	Etan	Ez
.000	1.2030E+00	-1.7781E+02	-1.7781E+02	-1.7660E+02	-2.2993E-04	-2.2993E-04	-2.2606E-04
.148	1.2030E+00	-1.7781E+02	-1.7781E+02	-1.7660E+02	-2.2993E-04	-2.2993E-04	-2.2606E-04
.296	1.2030E+00	-1.7781E+02	-1.7781E+02	-1.7660E+02	-2.2993E-04	-2.2993E-04	-2.2606E-04
.444	1.2030E+00	-1.7781E+02	-1.7781E+02	-1.7660E+02	-2.2993E-04	-2.2993E-04	-2.2606E-04
.592	1.2030E+00	-1.7781E+02	-1.7781E+02	-1.7660E+02	-2.2993E-04	-2.2993E-04	-2.2606E-04
.592	4.6496E+02	-1.7781E+02	3.5323E+02	1.5616E+02	-7.9003E-03	4.4311E-03	4.4350E-03
.621	4.2671E+02	-1.5334E+02	3.3270E+02	1.5973E+02	-7.3118E-03	3.8645E-03	4.4350E-03
.650	3.9323E+02	-1.3193E+02	3.1458E+02	1.6273E+02	-6.8025E-03	3.3736E-03	4.4350E-03
.679	3.6373E+02	-1.1309E+02	2.9848E+02	1.6518E+02	-6.3592E-03	2.9454E-03	4.4350E-03
.708	3.3764E+02	-9.6440E+01	2.8410E+02	1.6729E+02	-5.9708E-03	2.5697E-03	4.4350E-03
.737	3.1446E+02	-8.1643E+01	2.7118E+02	1.6908E+02	-5.6286E-03	2.2382E-03	4.4350E-03
.767	2.9377E+02	-6.8439E+01	2.5952E+02	1.7060E+02	-5.3258E-03	1.9443E-03	4.4350E-03
.796	2.7530E+02	-5.6611E+01	2.4899E+02	1.7200E+02	-5.0561E-03	1.6825E-03	4.4350E-03
.825	2.5883E+02	-4.5973E+01	2.3947E+02	1.7346E+02	-4.8144E-03	1.4483E-03	4.4350E-03
.854	2.4412E+02	-3.6372E+01	2.3084E+02	1.7496E+02	-4.5968E-03	1.2379E-03	4.4350E-03
.883	2.3089E+02	-2.7678E+01	2.2297E+02	1.7633E+02	-4.4008E-03	1.0483E-03	4.4350E-03
.912	2.1893E+02	-1.9780E+01	2.1577E+02	1.7749E+02	-4.2239E-03	8.7679E-04	4.4350E-03
.942	2.0807E+02	-1.2586E+01	2.0914E+02	1.7840E+02	-4.0640E-03	7.2114E-04	4.4350E-03
.971	1.9817E+02	-6.0156E+00	2.0303E+02	1.7912E+02	-3.9188E-03	5.7945E-04	4.4350E-03
1.000	1.8913E+02	.0000E+00	1.9738E+02	1.7963E+02	-3.7869E-03	4.5007E-04	4.4350E-03

```
   ************************************
   *                                  *
   *   F I D E P 2 - VERSION 6        *
   *                                  *
   ************************************

  ************ PROBLEM TITLE ************

SCS-6/TIMETAL21S(DBP) Inphase TMF - stress control

  --------- Average Stress Output ----------
```

STEP	TIME	TEMPERATURE	SZAPP	SZF	SZM	SZ90	EME-F	EME-M	EME-90	EZC
1	-3.5964E+03	8.9913E+02	.0000E+00	-7.8499E-01	4.2268E-01	.0000E+00	-1.8383E-06	5.2622E-06	.0000E+00	-5.8387E-06
10	-3.5640E+03	8.9125E+02	.0000E+00	-7.9102E+00	4.2593E+00	.0000E+00	-1.8505E-05	5.2320E-05	.0000E+00	-5.8509E-05
20	-3.5280E+03	8.8250E+02	.0000E+00	-1.5228E+01	8.1994E+00	.0000E+00	-3.5889E-05	1.0536E-04	.0000E+00	-1.1590E-04
30	-3.4920E+03	8.7375E+02	.0000E+00	-1.9586E+01	1.0546E+01	.0000E+00	-4.6503E-05	1.6477E-04	.0000E+00	-1.6651E-04
40	-3.4560E+03	8.6500E+02	.0000E+00	-2.2608E+01	1.2174E+01	.0000E+00	-5.4003E-05	2.2702E-04	.0000E+00	-2.1389E-04
50	-3.4200E+03	8.5625E+02	.0000E+00	-2.4385E+01	1.3130E+01	.0000E+00	-5.8528E-05	2.9198E-04	.0000E+00	-2.5817E-04
60	-3.3840E+03	8.4750E+02	.0000E+00	-2.5315E+01	1.3631E+01	.0000E+00	-6.0935E-05	3.5874E-04	.0000E+00	-3.0024E-04
70	-3.3480E+03	8.3875E+02	.0000E+00	-2.5871E+01	1.3931E+01	.0000E+00	-6.2366E-05	4.2616E-04	.0000E+00	-3.4124E-04
80	-3.3120E+03	8.3000E+02	.0000E+00	-2.6299E+01	1.4161E+01	.0000E+00	-6.3431E-05	4.9364E-04	.0000E+00	-3.8179E-04
90	-3.2760E+03	8.2125E+02	.0000E+00	-2.6681E+01	1.4367E+01	.0000E+00	-6.4352E-05	5.6096E-04	.0000E+00	-4.2211E-04
100	-3.2400E+03	8.1250E+02	.0000E+00	-2.7412E+01	1.4760E+01	.0000E+00	-6.6073E-05	6.2716E-04	.0000E+00	-4.6313E-04
110	-3.2040E+03	8.0375E+02	.0000E+00	-3.0194E+01	1.6259E+01	.0000E+00	-7.2593E-05	6.8824E-04	.0000E+00	-5.0887E-04
120	-3.1680E+03	7.9500E+02	.0000E+00	-3.3675E+01	1.8133E+01	.0000E+00	-8.0760E-05	7.4737E-04	.0000E+00	-5.5617E-04
130	-3.1320E+03	7.8625E+02	.0000E+00	-3.7502E+01	2.0193E+01	.0000E+00	-8.9745E-05	8.0537E-04	.0000E+00	-6.0419E-04
140	-3.0960E+03	7.7750E+02	.0000E+00	-4.1555E+01	2.2376E+01	.0000E+00	-9.9261E-05	8.6252E-04	.0000E+00	-6.5266E-04
150	-3.0600E+03	7.6875E+02	.0000E+00	-4.5781E+01	2.4651E+01	.0000E+00	-1.0918E-04	9.1896E-04	.0000E+00	-7.0144E-04
160	**-3.0240E+03**	**7.6000E+02**	**.0000E+00**	**-5.0148E+01**	**2.7003E+01**	**.0000E+00**	**-1.1941E-04**	**9.7477E-04**	**.0000E+00**	**-7.5045E-04**
170	-2.9880E+03	7.5125E+02	.0000E+00	-5.5315E+01	2.9785E+01	.0000E+00	-1.3143E-04	1.0284E-03	.0000E+00	-8.0103E-04
180	-2.9520E+03	7.4250E+02	.0000E+00	-6.1058E+01	3.2877E+01	.0000E+00	-1.4473E-04	1.0803E-03	.0000E+00	-8.5279E-04
190	-2.9160E+03	7.3375E+02	.0000E+00	-6.7255E+01	3.6214E+01	.0000E+00	-1.5904E-04	1.1310E-03	.0000E+00	-9.0545E-04
200	-2.8800E+03	7.2500E+02	.0000E+00	-7.3843E+01	3.9761E+01	.0000E+00	-1.7421E-04	1.1804E-03	.0000E+00	-9.5887E-04
210	-2.8440E+03	7.1625E+02	.0000E+00	-8.0781E+01	4.3497E+01	.0000E+00	-1.9014E-04	1.2288E-03	.0000E+00	-1.0129E-03
220	-2.8080E+03	7.0750E+02	.0000E+00	-8.8040E+01	4.7406E+01	.0000E+00	-2.0676E-04	1.2762E-03	.0000E+00	-1.0676E-03
230	-2.7720E+03	6.9875E+02	.0000E+00	-9.5598E+01	5.1476E+01	.0000E+00	-2.2400E-04	1.3226E-03	.0000E+00	-1.1228E-03
240	-2.7360E+03	6.9000E+02	.0000E+00	-1.0343E+02	5.5694E+01	.0000E+00	-2.4182E-04	1.3681E-03	.0000E+00	-1.1784E-03
250	-2.7000E+03	6.8125E+02	.0000E+00	-1.1152E+02	6.0051E+01	.0000E+00	-2.6016E-04	1.4127E-03	.0000E+00	-1.2345E-03
260	-2.6640E+03	6.7250E+02	.0000E+00	-1.1985E+02	6.4536E+01	.0000E+00	-2.7898E-04	1.4566E-03	.0000E+00	-1.2910E-03
270	**-2.6280E+03**	**6.6375E+02**	**.0000E+00**	**-1.2840E+02**	**6.9139E+01**	**.0000E+00**	**-2.9824E-04**	**1.4997E-03**	**.0000E+00**	**-1.3478E-03**
280	-2.5920E+03	6.5500E+02	.0000E+00	-1.3715E+02	7.3850E+01	.0000E+00	-3.1788E-04	1.5420E-03	.0000E+00	-1.4048E-03
290	-2.5560E+03	6.4625E+02	.0000E+00	-1.4600E+02	7.8615E+01	.0000E+00	-3.3771E-04	1.5838E-03	.0000E+00	-1.4619E-03
300	-2.5200E+03	6.3750E+02	.0000E+00	-1.5474E+02	8.3322E+01	.0000E+00	-3.5732E-04	1.6253E-03	.0000E+00	-1.5186E-03
310	-2.4840E+03	6.2875E+02	.0000E+00	-1.6352E+02	8.8048E+01	.0000E+00	-3.7696E-04	1.6664E-03	.0000E+00	-1.5752E-03
320	-2.4480E+03	6.2000E+02	.0000E+00	-1.7237E+02	9.2813E+01	.0000E+00	-3.9671E-04	1.7070E-03	.0000E+00	-1.6319E-03
330	-2.4120E+03	6.1125E+02	.0000E+00	-1.8130E+02	9.7622E+01	.0000E+00	-4.1660E-04	1.7472E-03	.0000E+00	-1.6885E-03
340	-2.3760E+03	6.0250E+02	.0000E+00	-1.9032E+02	1.0248E+02	.0000E+00	-4.3663E-04	1.7869E-03	.0000E+00	-1.7452E-03
350	-2.3400E+03	5.9375E+02	.0000E+00	-1.9966E+02	1.0751E+02	.0000E+00	-4.5725E-04	1.8255E-03	.0000E+00	-1.8023E-03
360	-2.3040E+03	5.8500E+02	.0000E+00	-2.0930E+02	1.1270E+02	.0000E+00	-4.7841E-04	1.8630E-03	.0000E+00	-1.8599E-03
370	-2.2680E+03	5.7625E+02	.0000E+00	-2.1900E+02	1.1792E+02	.0000E+00	-4.9966E-04	1.9002E-03	.0000E+00	-1.9174E-03
380	**-2.2320E+03**	**5.6750E+02**	**.0000E+00**	**-2.2868E+02**	**1.2314E+02**	**.0000E+00**	**-5.2082E-04**	**1.9370E-03**	**.0000E+00**	**-1.9748E-03**
390	-2.1960E+03	5.5875E+02	.0000E+00	-2.3838E+02	1.2836E+02	.0000E+00	-5.4198E-04	1.9734E-03	.0000E+00	-2.0320E-03
400	-2.1600E+03	5.5000E+02	.0000E+00	-2.4811E+02	1.3360E+02	.0000E+00	-5.6315E-04	2.0094E-03	.0000E+00	-2.0891E-03
410	**-2.1240E+03**	**5.4125E+02**	**.0000E+00**	**-2.5780E+02**	**1.3881E+02**	**.0000E+00**	**-5.8419E-04**	**2.0450E-03**	**.0000E+00**	**-2.1460E-03**
420	-2.0880E+03	5.3250E+02	.0000E+00	-2.6751E+02	1.4405E+02	.0000E+00	-6.0524E-04	2.0804E-03	.0000E+00	-2.2027E-03
430	**-2.0520E+03**	**5.2375E+02**	**.0000E+00**	**-2.7724E+02**	**1.4928E+02**	**.0000E+00**	**-6.2628E-04**	**2.1154E-03**	**.0000E+00**	**-2.2593E-03**
440	-2.0160E+03	5.1500E+02	.0000E+00	-2.8690E+02	1.5448E+02	.0000E+00	-6.4713E-04	2.1499E-03	.0000E+00	-2.3155E-03

450	-1.9800E+03	5.0625E+02	.0000E+00	-2.9657E+02	1.5969E+02	.0000E+00	-6.6796E-04	2.1842E-03	.0000E+00	-2.3716E-03
460	-1.9440E+03	4.9750E+02	.0000E+00	-3.0624E+02	1.6490E+02	.0000E+00	-6.8874E-04	2.2181E-03	.0000E+00	-2.4275E-03
470	-1.9080E+03	4.8875E+02	.0000E+00	-3.1588E+02	1.7009E+02	.0000E+00	-7.0942E-04	2.2518E-03	.0000E+00	-2.4833E-03
480	-1.8720E+03	4.8000E+02	.0000E+00	-3.2550E+02	1.7527E+02	.0000E+00	-7.3004E-04	2.2851E-03	.0000E+00	-2.5388E-03
490	-1.8360E+03	4.7125E+02	.0000E+00	-3.3509E+02	1.8043E+02	.0000E+00	-7.5051E-04	2.3180E-03	.0000E+00	-2.5941E-03
500	-1.8000E+03	4.6250E+02	.0000E+00	-3.4462E+02	1.8557E+02	.0000E+00	-7.7084E-04	2.3505E-03	.0000E+00	-2.6491E-03
510	-1.7640E+03	4.5375E+02	.0000E+00	-3.5403E+02	1.9063E+02	.0000E+00	-7.9087E-04	2.3827E-03	.0000E+00	-2.7036E-03
520	-1.7280E+03	4.4500E+02	.0000E+00	-3.6343E+02	1.9570E+02	.0000E+00	-8.1083E-04	2.4146E-03	.0000E+00	-2.7581E-03
530	-1.6920E+03	4.3625E+02	.0000E+00	-3.7283E+02	2.0075E+02	.0000E+00	-8.3074E-04	2.4461E-03	.0000E+00	-2.8123E-03
540	-1.6560E+03	4.2750E+02	.0000E+00	-3.8221E+02	2.0581E+02	.0000E+00	-8.5059E-04	2.4773E-03	.0000E+00	-2.8663E-03
550	-1.6200E+03	4.1875E+02	.0000E+00	-3.9159E+02	2.1086E+02	.0000E+00	-8.7038E-04	2.5081E-03	.0000E+00	-2.9202E-03
560	-1.5840E+03	4.1000E+02	.0000E+00	-4.0086E+02	2.1585E+02	.0000E+00	-8.8989E-04	2.5386E-03	.0000E+00	-2.9737E-03
570	-1.5480E+03	4.0125E+02	.0000E+00	-4.1003E+02	2.2079E+02	.0000E+00	-9.0918E-04	2.5687E-03	.0000E+00	-3.0269E-03
580	-1.5120E+03	3.9250E+02	.0000E+00	-4.1919E+02	2.2572E+02	.0000E+00	-9.2838E-04	2.5985E-03	.0000E+00	-3.0798E-03
590	-1.4760E+03	3.8375E+02	.0000E+00	-4.2833E+02	2.3064E+02	.0000E+00	-9.4751E-04	2.6279E-03	.0000E+00	-3.1325E-03
600	-1.4400E+03	3.7500E+02	.0000E+00	-4.3745E+02	2.3555E+02	.0000E+00	-9.6656E-04	2.6570E-03	.0000E+00	-3.1851E-03
610	-1.4040E+03	3.6625E+02	.0000E+00	-4.4654E+02	2.4045E+02	.0000E+00	-9.8552E-04	2.6858E-03	.0000E+00	-3.2374E-03
620	-1.3680E+03	3.5750E+02	.0000E+00	-4.5538E+02	2.4521E+02	.0000E+00	-1.0039E-03	2.7144E-03	.0000E+00	-3.2891E-03
630	-1.3320E+03	3.4875E+02	.0000E+00	-4.6415E+02	2.4993E+02	.0000E+00	-1.0221E-03	2.7427E-03	.0000E+00	-3.3404E-03
640	-1.2960E+03	3.4000E+02	.0000E+00	-4.7289E+02	2.5463E+02	.0000E+00	-1.0402E-03	2.7707E-03	.0000E+00	-3.3916E-03
650	-1.2600E+03	3.3125E+02	.0000E+00	-4.8160E+02	2.5932E+02	.0000E+00	-1.0582E-03	2.7983E-03	.0000E+00	-3.4425E-03
660	-1.2240E+03	3.2250E+02	.0000E+00	-4.9027E+02	2.6399E+02	.0000E+00	-1.0761E-03	2.8257E-03	.0000E+00	-3.4932E-03
670	-1.1880E+03	3.1375E+02	.0000E+00	-4.9886E+02	2.6862E+02	.0000E+00	-1.0938E-03	2.8526E-03	.0000E+00	-3.5436E-03
680	-1.1520E+03	3.0500E+02	.0000E+00	-5.0718E+02	2.7310E+02	.0000E+00	-1.1108E-03	2.8792E-03	.0000E+00	-3.5934E-03
690	-1.1160E+03	2.9625E+02	.0000E+00	-5.1545E+02	2.7755E+02	.0000E+00	-1.1278E-03	2.9054E-03	.0000E+00	-3.6430E-03
700	-1.0800E+03	2.8750E+02	.0000E+00	-5.2368E+02	2.8198E+02	.0000E+00	-1.1446E-03	2.9312E-03	.0000E+00	-3.6923E-03
710	-1.0440E+03	2.7875E+02	.0000E+00	-5.3187E+02	2.8639E+02	.0000E+00	-1.1613E-03	2.9568E-03	.0000E+00	-3.7415E-03
720	-1.0080E+03	2.7000E+02	.0000E+00	-5.4001E+02	2.9077E+02	.0000E+00	-1.1778E-03	2.9820E-03	.0000E+00	-3.7903E-03
730	-9.7200E+02	2.6125E+02	.0000E+00	-5.4810E+02	2.9513E+02	.0000E+00	-1.1943E-03	3.0069E-03	.0000E+00	-3.8390E-03
740	-9.3600E+02	2.5250E+02	.0000E+00	-5.5546E+02	2.9909E+02	.0000E+00	-1.2091E-03	3.0316E-03	.0000E+00	-3.8859E-03
750	-9.0000E+02	2.4375E+02	.0000E+00	-5.6263E+02	3.0296E+02	.0000E+00	-1.2236E-03	3.0560E-03	.0000E+00	-3.9324E-03
760	-8.6400E+02	2.3500E+02	.0000E+00	-5.6974E+02	3.0678E+02	.0000E+00	-1.2379E-03	3.0801E-03	.0000E+00	-3.9785E-03
770	-8.2800E+02	2.2625E+02	.0000E+00	-5.7678E+02	3.1058E+02	.0000E+00	-1.2520E-03	3.1039E-03	.0000E+00	-4.0244E-03
780	-7.9200E+02	2.1750E+02	.0000E+00	-5.8376E+02	3.1433E+02	.0000E+00	-1.2660E-03	3.1273E-03	.0000E+00	-4.0700E-03
790	-7.5600E+02	2.0875E+02	.0000E+00	-5.9066E+02	3.1805E+02	.0000E+00	-1.2798E-03	3.1504E-03	.0000E+00	-4.1153E-03
800	-7.2000E+02	2.0000E+02	.0000E+00	-5.9745E+02	3.2170E+02	.0000E+00	-1.2933E-03	3.1730E-03	.0000E+00	-4.1605E-03
810	-6.8400E+02	1.9125E+02	.0000E+00	-6.0411E+02	3.2529E+02	.0000E+00	-1.3065E-03	3.1951E-03	.0000E+00	-4.2057E-03
820	-6.4800E+02	1.8250E+02	.0000E+00	-6.1070E+02	3.2884E+02	.0000E+00	-1.3195E-03	3.2168E-03	.0000E+00	-4.2506E-03
830	-6.1200E+02	1.7375E+02	.0000E+00	-6.1723E+02	3.3235E+02	.0000E+00	-1.3324E-03	3.2382E-03	.0000E+00	-4.2952E-03
840	-5.7600E+02	1.6500E+02	.0000E+00	-6.2367E+02	3.3582E+02	.0000E+00	-1.3451E-03	3.2593E-03	.0000E+00	-4.3395E-03
850	-5.4000E+02	1.5625E+02	.0000E+00	-6.3005E+02	3.3926E+02	.0000E+00	-1.3576E-03	3.2800E-03	.0000E+00	-4.3836E-03
860	-5.0400E+02	1.4750E+02	.0000E+00	-6.3635E+02	3.4265E+02	.0000E+00	-1.3699E-03	3.3004E-03	.0000E+00	-4.4274E-03
870	-4.6800E+02	1.3875E+02	.0000E+00	-6.4258E+02	3.4601E+02	.0000E+00	-1.3821E-03	3.3205E-03	.0000E+00	-4.4709E-03
880	-4.3200E+02	1.3000E+02	.0000E+00	-6.4874E+02	3.4932E+02	.0000E+00	-1.3941E-03	3.3403E-03	.0000E+00	-4.5141E-03
890	-3.9600E+02	1.2125E+02	.0000E+00	-6.5482E+02	3.5260E+02	.0000E+00	-1.4059E-03	3.3597E-03	.0000E+00	-4.5571E-03
900	-3.6000E+02	1.1250E+02	.0000E+00	-6.6083E+02	3.5583E+02	.0000E+00	-1.4175E-03	3.3788E-03	.0000E+00	-4.5998E-03
910	-3.2400E+02	1.0375E+02	.0000E+00	-6.6676E+02	3.5903E+02	.0000E+00	-1.4290E-03	3.3976E-03	.0000E+00	-4.6422E-03
920	-2.8800E+02	9.5000E+01	.0000E+00	-6.7262E+02	3.6218E+02	.0000E+00	-1.4402E-03	3.4160E-03	.0000E+00	-4.6844E-03
930	-2.5200E+02	8.6250E+01	.0000E+00	-6.7833E+02	3.6525E+02	.0000E+00	-1.4510E-03	3.4338E-03	.0000E+00	-4.7265E-03
940	-2.1600E+02	7.7500E+01	.0000E+00	-6.8394E+02	3.6827E+02	.0000E+00	-1.4616E-03	3.4512E-03	.0000E+00	-4.7685E-03
950	-1.8000E+02	6.8750E+01	.0000E+00	-6.8947E+02	3.7125E+02	.0000E+00	-1.4719E-03	3.4683E-03	.0000E+00	-4.8101E-03
960	-1.4400E+02	6.0000E+01	.0000E+00	-6.9492E+02	3.7419E+02	.0000E+00	-1.4821E-03	3.4851E-03	.0000E+00	-4.8516E-03
970	-1.0800E+02	5.1250E+01	.0000E+00	-7.0030E+02	3.7708E+02	.0000E+00	-1.4921E-03	3.5015E-03	.0000E+00	-4.8927E-03
980	-7.2000E+01	4.2500E+01	.0000E+00	-7.0559E+02	3.7993E+02	.0000E+00	-1.5019E-03	3.5176E-03	.0000E+00	-4.9336E-03
990	-3.6000E+01	3.3750E+01	.0000E+00	-7.1081E+02	3.8274E+02	.0000E+00	-1.5115E-03	3.5333E-03	.0000E+00	-4.9742E-03
1000	.0000E+00	2.5000E+01	.0000E+00	-7.1595E+02	3.8551E+02	.0000E+00	-1.5209E-03	3.5487E-03	.0000E+00	-5.0145E-03
1010	9.0000E+00	3.1250E+01	2.5000E+00	-7.0764E+02	3.8488E+02	.0000E+00	-1.5023E-03	3.5496E-03	.0000E+00	-4.9739E-03
1020	1.8000E+01	3.7500E+01	5.0000E+00	-6.9930E+02	3.8424E+02	.0000E+00	-1.4836E-03	3.5504E-03	.0000E+00	-4.9330E-03
1030	2.7000E+01	4.3750E+01	7.5000E+00	-6.9092E+02	3.8357E+02	.0000E+00	-1.4648E-03	3.5510E-03	.0000E+00	-4.8921E-03
1040	3.6000E+01	5.0000E+01	1.0000E+01	-6.8249E+02	3.8288E+02	.0000E+00	-1.4458E-03	3.5515E-03	.0000E+00	-4.8509E-03
1050	4.5000E+01	5.6250E+01	1.2500E+01	-6.7402E+02	3.8217E+02	.0000E+00	-1.4268E-03	3.5518E-03	.0000E+00	-4.8096E-03

1060	5.4000E+01	6.2500E+01	1.5000E+01	-6.6551E+02	3.8143E+02	.0000E+00	-1.4076E-03	3.5519E-03	.0000E+00	-4.7682E-03
1070	6.3000E+01	6.8750E+01	1.7500E+01	-6.5696E+02	3.8067E+02	.0000E+00	-1.3884E-03	3.5519E-03	.0000E+00	-4.7266E-03
1080	7.2000E+01	7.5000E+01	2.0000E+01	-6.4837E+02	3.7989E+02	.0000E+00	-1.3690E-03	3.5517E-03	.0000E+00	-4.6848E-03
1090	8.1000E+01	8.1250E+01	2.2500E+01	-6.3974E+02	3.7909E+02	.0000E+00	-1.3495E-03	3.5514E-03	.0000E+00	-4.6429E-03
1100	9.0000E+01	8.7500E+01	2.5000E+01	-6.3107E+02	3.7827E+02	.0000E+00	-1.3299E-03	3.5510E-03	.0000E+00	-4.6008E-03
1110	9.9000E+01	9.3750E+01	2.7500E+01	-6.2235E+02	3.7742E+02	.0000E+00	-1.3101E-03	3.5503E-03	.0000E+00	-4.5586E-03
1120	1.0800E+02	1.0000E+02	3.0000E+01	-6.1353E+02	3.7651E+02	.0000E+00	-1.2900E-03	3.5493E-03	.0000E+00	-4.5165E-03
1130	1.1700E+02	1.0625E+02	3.2500E+01	-6.0466E+02	3.7559E+02	.0000E+00	-1.2698E-03	3.5481E-03	.0000E+00	-4.4742E-03
1140	1.2600E+02	1.1250E+02	3.5000E+01	-5.9576E+02	3.7464E+02	.0000E+00	-1.2495E-03	3.5468E-03	.0000E+00	-4.4318E-03
1150	1.3500E+02	1.1875E+02	3.7500E+01	-5.8682E+02	3.7367E+02	.0000E+00	-1.2291E-03	3.5453E-03	.0000E+00	-4.3892E-03
1160	1.4400E+02	1.2500E+02	4.0000E+01	-5.7784E+02	3.7268E+02	.0000E+00	-1.2086E-03	3.5437E-03	.0000E+00	-4.3464E-03
1170	1.5300E+02	1.3125E+02	4.2500E+01	-5.6882E+02	3.7167E+02	.0000E+00	-1.1879E-03	3.5419E-03	.0000E+00	-4.3035E-03
1180	1.6200E+02	1.3750E+02	4.5000E+01	-5.5976E+02	3.7064E+02	.0000E+00	-1.1672E-03	3.5400E-03	.0000E+00	-4.2605E-03
1190	1.7100E+02	1.4375E+02	4.7500E+01	-5.5067E+02	3.6959E+02	.0000E+00	-1.1464E-03	3.5379E-03	.0000E+00	-4.2172E-03
1200	1.8000E+02	1.5000E+02	5.0000E+01	-5.4153E+02	3.6852E+02	.0000E+00	-1.1254E-03	3.5357E-03	.0000E+00	-4.1738E-03
1210	1.8900E+02	1.7500E+02	7.2500E+01	-4.8134E+02	3.7072E+02	.0000E+00	-9.8007E-04	3.5857E-03	.0000E+00	-3.9383E-03
1220	1.9800E+02	2.0000E+02	9.5000E+01	-4.2051E+02	3.7258E+02	.0000E+00	-8.3268E-04	3.6336E-03	.0000E+00	-3.7000E-03
1230	2.0700E+02	2.2500E+02	1.1750E+02	-3.5882E+02	3.7398E+02	.0000E+00	-6.8273E-04	3.6785E-03	.0000E+00	-3.4596E-03
1240	2.1600E+02	2.5000E+02	1.4000E+02	-2.9648E+02	3.7503E+02	.0000E+00	-5.3064E-04	3.7213E-03	.0000E+00	-3.2166E-03
1250	2.2500E+02	2.7500E+02	1.6250E+02	-2.3195E+02	3.7489E+02	.0000E+00	-3.7308E-04	3.7629E-03	.0000E+00	-2.9671E-03
1260	2.3400E+02	3.0000E+02	1.8500E+02	-1.6580E+02	3.7389E+02	.0000E+00	-2.1119E-04	3.8035E-03	.0000E+00	-2.7124E-03
1270	2.4300E+02	3.2500E+02	2.0750E+02	-9.8742E+01	3.7240E+02	.0000E+00	-4.6437E-05	3.8424E-03	.0000E+00	-2.4542E-03
1280	2.5200E+02	3.5000E+02	2.3000E+02	-3.0602E+01	3.7032E+02	.0000E+00	1.2158E-04	3.8797E-03	.0000E+00	-2.1920E-03
1290	2.6100E+02	3.7500E+02	2.5250E+02	3.8446E+01	3.6776E+02	.0000E+00	2.9253E-04	3.9161E-03	.0000E+00	-1.9260E-03
1300	2.7000E+02	4.0000E+02	2.7500E+02	1.0860E+02	3.6460E+02	.0000E+00	4.6690E-04	3.9518E-03	.0000E+00	-1.6556E-03
1310	2.7900E+02	4.2500E+02	2.9750E+02	1.7946E+02	3.6106E+02	.0000E+00	6.4385E-04	3.9862E-03	.0000E+00	-1.3816E-03
1320	2.8800E+02	4.5000E+02	3.2000E+02	2.5114E+02	3.5708E+02	.0000E+00	8.2367E-04	4.0195E-03	.0000E+00	-1.1039E-03
1330	2.9700E+02	4.7500E+02	3.4250E+02	3.2352E+02	3.5272E+02	.0000E+00	1.0061E-03	4.0518E-03	.0000E+00	-8.2251E-04
1340	3.0600E+02	5.0000E+02	3.6500E+02	3.9789E+02	3.4729E+02	.0000E+00	1.1942E-03	4.0854E-03	.0000E+00	-5.3457E-04
1350	3.1500E+02	5.2500E+02	3.8750E+02	4.8082E+02	3.3725E+02	.0000E+00	1.4046E-03	4.1383E-03	.0000E+00	-2.2335E-04
1360	3.2400E+02	5.5000E+02	4.1000E+02	5.6419E+02	3.2697E+02	.0000E+00	1.6174E-03	4.1900E-03	.0000E+00	9.1454E-05
1370	3.3300E+02	5.7500E+02	4.3250E+02	6.4814E+02	3.1638E+02	.0000E+00	1.8331E-03	4.2413E-03	.0000E+00	4.1019E-04
1380	3.4200E+02	6.0000E+02	4.5500E+02	7.4348E+02	2.9966E+02	.0000E+00	2.0793E-03	4.3198E-03	.0000E+00	7.6035E-04
1390	3.5100E+02	6.2500E+02	4.7750E+02	8.6605E+02	2.6828E+02	.0000E+00	2.3978E-03	4.4671E-03	.0000E+00	1.1837E-03
1400	3.6000E+02	6.5000E+02	5.0000E+02	1.0297E+03	2.1476E+02	.0000E+00	2.8271E-03	4.7223E-03	.0000E+00	1.7188E-03
1410	3.6900E+02	6.2500E+02	4.7750E+02	9.7267E+02	2.1087E+02	.0000E+00	2.6759E-03	4.7452E-03	.0000E+00	1.4618E-03
1420	3.7800E+02	6.0000E+02	4.5500E+02	9.0504E+02	2.1267E+02	.0000E+00	2.4982E-03	4.7387E-03	.0000E+00	1.1792E-03
1430	3.8700E+02	5.7500E+02	4.3250E+02	8.3201E+02	2.1738E+02	.0000E+00	2.3078E-03	4.7160E-03	.0000E+00	8.8487E-04
1440	3.9600E+02	5.5000E+02	4.1000E+02	7.5925E+02	2.2194E+02	.0000E+00	2.1192E-03	4.6917E-03	.0000E+00	5.9322E-04
1450	4.0500E+02	5.2500E+02	3.8750E+02	6.8701E+02	2.2622E+02	.0000E+00	1.9330E-03	4.6667E-03	.0000E+00	3.0505E-04
1460	4.1400E+02	5.0000E+02	3.6500E+02	6.1542E+02	2.3016E+02	.0000E+00	1.7494E-03	4.6406E-03	.0000E+00	2.0602E-05
1470	4.2300E+02	4.7500E+02	3.4250E+02	5.4443E+02	2.3377E+02	.0000E+00	1.5682E-03	4.6139E-03	.0000E+00	-2.6042E-04
1480	4.3200E+02	4.5000E+02	3.2000E+02	4.7428E+02	2.3693E+02	.0000E+00	1.3900E-03	4.5859E-03	.0000E+00	-5.3751E-04
1490	4.4100E+02	4.2500E+02	2.9750E+02	4.0474E+02	2.3975E+02	.0000E+00	1.2142E-03	4.5566E-03	.0000E+00	-8.1126E-04
1500	4.5000E+02	4.0000E+02	2.7500E+02	3.3592E+02	2.4220E+02	.0000E+00	1.0410E-03	4.5259E-03	.0000E+00	-1.0815E-03
1510	4.5900E+02	3.7500E+02	2.5250E+02	2.6773E+02	2.4430E+02	.0000E+00	8.7020E-04	4.4938E-03	.0000E+00	-1.3483E-03
1520	4.6800E+02	3.5000E+02	2.3000E+02	2.0046E+02	2.4591E+02	.0000E+00	7.0232E-04	4.4605E-03	.0000E+00	-1.6113E-03
1530	4.7700E+02	3.2500E+02	2.0750E+02	1.3397E+02	2.4709E+02	.0000E+00	5.3705E-04	4.4259E-03	.0000E+00	-1.8707E-03
1540	4.8600E+02	3.0000E+02	1.8500E+02	6.8443E+01	2.4776E+02	.0000E+00	3.7472E-04	4.3894E-03	.0000E+00	-2.1265E-03
1550	4.9500E+02	2.7500E+02	1.6250E+02	3.7437E+00	2.4798E+02	.0000E+00	2.1503E-04	4.3510E-03	.0000E+00	-2.3790E-03
1560	5.0400E+02	2.5000E+02	1.4000E+02	-5.9601E+01	2.4748E+02	.0000E+00	5.9021E-05	4.3109E-03	.0000E+00	-2.6269E-03
1570	5.1300E+02	2.2500E+02	1.1750E+02	-1.2114E+02	2.4600E+02	.0000E+00	-9.2463E-05	4.2688E-03	.0000E+00	-2.8694E-03
1580	5.2200E+02	2.0000E+02	9.5000E+01	-1.8203E+02	2.4417E+02	.0000E+00	-2.4182E-04	4.2244E-03	.0000E+00	-3.1091E-03
1590	5.3100E+02	1.7500E+02	7.2500E+01	-2.4206E+02	2.4188E+02	.0000E+00	-3.8861E-04	4.1771E-03	.0000E+00	-3.3469E-03
1600	5.4000E+02	1.5000E+02	5.0000E+01	-3.0146E+02	2.3925E+02	.0000E+00	-5.3335E-04	4.1277E-03	.0000E+00	-3.5818E-03
1610	5.4900E+02	1.7500E+02	7.2500E+01	-2.4206E+02	2.4188E+02	.0000E+00	-3.8861E-04	4.1771E-03	.0000E+00	-3.3469E-03
1620	5.5800E+02	2.0000E+02	9.5000E+01	-1.8203E+02	2.4417E+02	.0000E+00	-2.4182E-04	4.2244E-03	.0000E+00	-3.1091E-03
1630	5.6700E+02	2.2500E+02	1.1750E+02	-1.2114E+02	2.4600E+02	.0000E+00	-9.2463E-05	4.2688E-03	.0000E+00	-2.8694E-03
1640	5.7600E+02	2.5000E+02	1.4000E+02	-5.9601E+01	2.4748E+02	.0000E+00	5.9021E-05	4.3109E-03	.0000E+00	-2.6269E-03
1650	5.8500E+02	2.7500E+02	1.6250E+02	3.7437E+00	2.4798E+02	.0000E+00	2.1503E-04	4.3510E-03	.0000E+00	-2.3790E-03
1660	5.9400E+02	3.0000E+02	1.8500E+02	6.8443E+01	2.4776E+02	.0000E+00	3.7472E-04	4.3894E-03	.0000E+00	-2.1265E-03

1670	6.0300E+02	3.2500E+02	2.0750E+02	1.3397E+02	2.4709E+02	.0000E+00	5.3705E-04	4.4259E-03	.0000E+00	-1.8707E-03
1680	6.1200E+02	3.5000E+02	2.3000E+02	2.0046E+02	2.4591E+02	.0000E+00	7.0232E-04	4.4605E-03	.0000E+00	-1.6113E-03
1690	6.2100E+02	3.7500E+02	2.5250E+02	2.6773E+02	2.4430E+02	.0000E+00	8.7020E-04	4.4938E-03	.0000E+00	-1.3483E-03
1700	6.3000E+02	4.0000E+02	2.7500E+02	3.3592E+02	2.4220E+02	.0000E+00	1.0410E-03	4.5259E-03	.0000E+00	-1.0815E-03
1710	6.3900E+02	4.2500E+02	2.9750E+02	4.0474E+02	2.3975E+02	.0000E+00	1.2142E-03	4.5566E-03	.0000E+00	-8.1126E-04
1720	6.4800E+02	4.5000E+02	3.2000E+02	4.7428E+02	2.3693E+02	.0000E+00	1.3900E-03	4.5859E-03	.0000E+00	-5.3751E-04
1730	6.5700E+02	4.7500E+02	3.4250E+02	5.4443E+02	2.3377E+02	.0000E+00	1.5682E-03	4.6139E-03	.0000E+00	-2.6042E-04
1740	6.6600E+02	5.0000E+02	3.6500E+02	6.1542E+02	2.3016E+02	.0000E+00	1.7494E-03	4.6406E-03	.0000E+00	2.0602E-05
1750	6.7500E+02	5.2500E+02	3.8750E+02	6.8701E+02	2.2622E+02	.0000E+00	1.9330E-03	4.6667E-03	.0000E+00	3.0505E-04
1760	6.8400E+02	5.5000E+02	4.1000E+02	7.5925E+02	2.2194E+02	.0000E+00	2.1192E-03	4.6917E-03	.0000E+00	5.9322E-04
1770	6.9300E+02	5.7500E+02	4.3250E+02	8.3215E+02	2.1730E+02	.0000E+00	2.3081E-03	4.7163E-03	.0000E+00	8.8519E-04
1780	7.0200E+02	6.0000E+02	4.5500E+02	9.1256E+02	2.0862E+02	.0000E+00	2.5171E-03	4.7576E-03	.0000E+00	1.1981E-03
1790	7.1100E+02	6.2500E+02	4.7750E+02	9.9579E+02	1.9842E+02	.0000E+00	2.7348E-03	4.8041E-03	.0000E+00	1.5207E-03
1800	7.2000E+02	6.5000E+02	5.0000E+02	1.0881E+03	1.8332E+02	.0000E+00	2.9781E-03	4.8733E-03	.0000E+00	1.8698E-03
1810	7.2900E+02	6.2500E+02	4.7750E+02	1.0234E+03	1.8357E+02	.0000E+00	2.8066E-03	4.8758E-03	.0000E+00	1.5925E-03
1820	7.3800E+02	6.0000E+02	4.5500E+02	9.5258E+02	1.8707E+02	.0000E+00	2.6205E-03	4.8610E-03	.0000E+00	1.3015E-03
1830	7.4700E+02	5.7500E+02	4.3250E+02	8.8003E+02	1.9152E+02	.0000E+00	2.4310E-03	4.8392E-03	.0000E+00	1.0081E-03
1840	7.5600E+02	5.5000E+02	4.1000E+02	8.0791E+02	1.9574E+02	.0000E+00	2.2437E-03	4.8162E-03	.0000E+00	7.1774E-04
1850	7.6500E+02	5.2500E+02	3.8750E+02	7.3630E+02	1.9969E+02	.0000E+00	2.0588E-03	4.7925E-03	.0000E+00	4.3083E-04
1860	7.7400E+02	5.0000E+02	3.6500E+02	6.6529E+02	2.0331E+02	.0000E+00	1.8763E-03	4.7676E-03	.0000E+00	1.4756E-04
1870	7.8300E+02	4.7500E+02	3.4250E+02	5.9484E+02	2.0662E+02	.0000E+00	1.6963E-03	4.7419E-03	.0000E+00	-1.3239E-04
1880	7.9200E+02	4.5000E+02	3.2000E+02	5.2520E+02	2.0951E+02	.0000E+00	1.5190E-03	4.7149E-03	.0000E+00	-4.0851E-04
1890	8.0100E+02	4.2500E+02	2.9750E+02	4.5615E+02	2.1207E+02	.0000E+00	1.3442E-03	4.6865E-03	.0000E+00	-6.8134E-04
1900	8.1000E+02	4.0000E+02	2.7500E+02	3.8779E+02	2.1427E+02	.0000E+00	1.1718E-03	4.6567E-03	.0000E+00	-9.5069E-04
1910	8.1900E+02	3.7500E+02	2.5250E+02	3.2005E+02	2.1612E+02	.0000E+00	1.0018E-03	4.6253E-03	.0000E+00	-1.2168E-03
1920	8.2800E+02	3.5000E+02	2.3000E+02	2.5319E+02	2.1751E+02	.0000E+00	8.3460E-04	4.5928E-03	.0000E+00	-1.4790E-03
1930	**8.3700E+02**	**3.2500E+02**	**2.0750E+02**	**1.8708E+02**	**2.1849E+02**	**.0000E+00**	**6.6995E-04**	**4.5588E-03**	**.0000E+00**	**-1.7378E-03**
1940	8.4600E+02	3.0000E+02	1.8500E+02	1.2190E+02	2.1898E+02	.0000E+00	5.0817E-04	4.5229E-03	.0000E+00	-1.9931E-03
1950	8.5500E+02	2.7500E+02	1.6250E+02	5.7533E+01	2.1902E+02	.0000E+00	3.4899E-04	4.4850E-03	.0000E+00	-2.2450E-03
1960	8.6400E+02	2.5000E+02	1.4000E+02	-5.5415E+00	2.1837E+02	.0000E+00	1.9333E-04	4.4452E-03	.0000E+00	-2.4926E-03
1970	8.7300E+02	2.2500E+02	1.1750E+02	-6.6900E+01	2.1679E+02	.0000E+00	4.1986E-05	4.4032E-03	.0000E+00	-2.7349E-03
1980	8.8200E+02	2.0000E+02	9.5000E+01	-1.2761E+02	2.1487E+02	.0000E+00	-1.0724E-04	4.3590E-03	.0000E+00	-2.9745E-03
1990	8.9100E+02	1.7500E+02	7.2500E+01	-1.8746E+02	2.1248E+02	.0000E+00	-2.5389E-04	4.3118E-03	.0000E+00	-3.2121E-03
2000	9.0000E+02	1.5000E+02	5.0000E+01	-2.4667E+02	2.0974E+02	.0000E+00	-3.9849E-04	4.2626E-03	.0000E+00	-3.4469E-03
2010	9.0900E+02	1.7500E+02	7.2500E+01	-1.8746E+02	2.1248E+02	.0000E+00	-2.5389E-04	4.3118E-03	.0000E+00	-3.2121E-03
2020	9.1800E+02	2.0000E+02	9.5000E+01	-1.2761E+02	2.1487E+02	.0000E+00	-1.0724E-04	4.3590E-03	.0000E+00	-2.9745E-03
2030	9.2700E+02	2.2500E+02	1.1750E+02	-6.6900E+01	2.1679E+02	.0000E+00	4.1986E-05	4.4032E-03	.0000E+00	-2.7349E-03
2040	9.3600E+02	2.5000E+02	1.4000E+02	-5.5415E+00	2.1837E+02	.0000E+00	1.9333E-04	4.4452E-03	.0000E+00	-2.4926E-03
2050	9.4500E+02	2.7500E+02	1.6250E+02	5.7533E+01	2.1902E+02	.0000E+00	3.4899E-04	4.4850E-03	.0000E+00	-2.2450E-03
2060	9.5400E+02	3.0000E+02	1.8500E+02	1.2190E+02	2.1898E+02	.0000E+00	5.0817E-04	4.5229E-03	.0000E+00	-1.9931E-03
2070	9.6300E+02	3.2500E+02	2.0750E+02	1.8708E+02	2.1849E+02	.0000E+00	6.6995E-04	4.5588E-03	.0000E+00	-1.7378E-03
2080	9.7200E+02	3.5000E+02	2.3000E+02	2.5319E+02	2.1751E+02	.0000E+00	8.3460E-04	4.5928E-03	.0000E+00	-1.4790E-03
2090	9.8100E+02	3.7500E+02	2.5250E+02	3.2005E+02	2.1612E+02	.0000E+00	1.0018E-03	4.6253E-03	.0000E+00	-1.2168E-03
2100	9.9000E+02	4.0000E+02	2.7500E+02	3.8779E+02	2.1427E+02	.0000E+00	1.1718E-03	4.6567E-03	.0000E+00	-9.5069E-04
2110	9.9900E+02	4.2500E+02	2.9750E+02	4.5615E+02	2.1207E+02	.0000E+00	1.3442E-03	4.6865E-03	.0000E+00	-6.8134E-04
2120	1.0080E+03	4.5000E+02	3.2000E+02	5.2520E+02	2.0951E+02	.0000E+00	1.5190E-03	4.7149E-03	.0000E+00	-4.0851E-04
2130	1.0170E+03	4.7500E+02	3.4250E+02	5.9484E+02	2.0662E+02	.0000E+00	1.6963E-03	4.7419E-03	.0000E+00	-1.3239E-04
2140	1.0260E+03	5.0000E+02	3.6500E+02	6.6529E+02	2.0331E+02	.0000E+00	1.8763E-03	4.7676E-03	.0000E+00	1.4756E-04
2150	**1.0350E+03**	**5.2500E+02**	**3.8750E+02**	**7.3630E+02**	**1.9969E+02**	**.0000E+00**	**2.0588E-03**	**4.7925E-03**	**.0000E+00**	**4.3083E-04**
2160	1.0440E+03	5.5000E+02	4.1000E+02	8.0791E+02	1.9574E+02	.0000E+00	2.2437E-03	4.8162E-03	.0000E+00	7.1774E-04
2170	1.0530E+03	5.7500E+02	4.3250E+02	8.8003E+02	1.9152E+02	.0000E+00	2.4310E-03	4.8392E-03	.0000E+00	1.0081E-03
2180	1.0620E+03	6.0000E+02	4.5500E+02	9.5646E+02	1.8498E+02	.0000E+00	2.6302E-03	4.8707E-03	.0000E+00	1.3112E-03
2190	1.0710E+03	6.2500E+02	4.7750E+02	1.0356E+03	1.7696E+02	.0000E+00	2.8378E-03	4.9070E-03	.0000E+00	1.6237E-03
2200	**1.0800E+03**	**6.5000E+02**	**5.0000E+02**	**1.1206E+03**	**1.6584E+02**	**.0000E+00**	**3.0620E-03**	**4.9572E-03**	**.0000E+00**	**1.9537E-03**
2210	1.0890E+03	6.2500E+02	4.7750E+02	1.0521E+03	1.6807E+02	.0000E+00	2.8807E-03	4.9500E-03	.0000E+00	1.6666E-03
2220	1.0980E+03	6.0000E+02	4.5500E+02	9.8042E+02	1.7208E+02	.0000E+00	2.6920E-03	4.9326E-03	.0000E+00	1.3731E-03
2230	1.1070E+03	5.7500E+02	4.3250E+02	9.0823E+02	1.7634E+02	.0000E+00	2.5033E-03	4.9115E-03	.0000E+00	1.0804E-03
2240	1.1160E+03	5.5000E+02	4.1000E+02	8.3649E+02	1.8035E+02	.0000E+00	2.3168E-03	4.8893E-03	.0000E+00	7.9085E-04
2250	1.1250E+03	5.2500E+02	3.8750E+02	7.6524E+02	1.8410E+02	.0000E+00	2.1326E-03	4.8663E-03	.0000E+00	5.0467E-04
2260	1.1340E+03	5.0000E+02	3.6500E+02	6.9457E+02	1.8754E+02	.0000E+00	1.9509E-03	4.8421E-03	.0000E+00	2.2208E-04

2270	1.1430E+03	4.7500E+02	3.4250E+02	6.2445E+02	1.9068E+02	.0000E+00	1.7714E-03	4.8171E-03	.0000E+00	-5.7225E-05
2280	1.1520E+03	4.5000E+02	3.2000E+02	5.5511E+02	1.9340E+02	.0000E+00	1.5948E-03	4.7906E-03	.0000E+00	-3.3277E-04
2290	1.1610E+03	4.2500E+02	2.9750E+02	4.8635E+02	1.9581E+02	.0000E+00	1.4204E-03	4.7628E-03	.0000E+00	-6.0506E-04
2300	1.1700E+03	4.0000E+02	2.7500E+02	4.1826E+02	1.9786E+02	.0000E+00	1.2486E-03	4.7335E-03	.0000E+00	-8.7392E-04
2310	1.1790E+03	3.7500E+02	2.5250E+02	3.5078E+02	1.9958E+02	.0000E+00	1.0790E-03	4.7026E-03	.0000E+00	-1.1395E-03
2320	1.1880E+03	3.5000E+02	2.3000E+02	2.8416E+02	2.0084E+02	.0000E+00	9.1225E-04	4.6704E-03	.0000E+00	-1.4014E-03
2330	1.1970E+03	3.2500E+02	2.0750E+02	2.1827E+02	2.0170E+02	.0000E+00	7.4797E-04	4.6368E-03	.0000E+00	-1.6598E-03
2340	1.2060E+03	3.0000E+02	1.8500E+02	1.5330E+02	2.0207E+02	.0000E+00	5.8652E-04	4.6012E-03	.0000E+00	-1.9147E-03
2350	1.2150E+03	2.7500E+02	1.6250E+02	8.9122E+01	2.0201E+02	.0000E+00	4.2763E-04	4.5636E-03	.0000E+00	-2.1664E-03
2360	1.2240E+03	2.5000E+02	1.4000E+02	2.6206E+01	2.0127E+02	.0000E+00	2.7218E-04	4.5241E-03	.0000E+00	-2.4137E-03
2370	1.2330E+03	2.2500E+02	1.1750E+02	-3.5045E+01	1.9964E+02	.0000E+00	1.2092E-04	4.4822E-03	.0000E+00	-2.6560E-03
2380	1.2420E+03	2.0000E+02	9.5000E+01	-9.5647E+01	1.9766E+02	.0000E+00	-2.8226E-05	4.4380E-03	.0000E+00	-2.8955E-03
2390	1.2510E+03	1.7500E+02	7.2500E+01	-1.5539E+02	1.9521E+02	.0000E+00	-1.7480E-04	4.3909E-03	.0000E+00	-3.1331E-03
2400	1.2600E+03	1.5000E+02	5.0000E+01	-2.1449E+02	1.9242E+02	.0000E+00	-3.1933E-04	4.3417E-03	.0000E+00	-3.3678E-03
2410	1.2690E+03	1.7500E+02	7.2500E+01	-1.5539E+02	1.9521E+02	.0000E+00	-1.7480E-04	4.3909E-03	.0000E+00	-3.1331E-03
2420	1.2780E+03	2.0000E+02	9.5000E+01	-9.5647E+01	1.9766E+02	.0000E+00	-2.8226E-05	4.4380E-03	.0000E+00	-2.8955E-03
2430	1.2870E+03	2.2500E+02	1.1750E+02	-3.5045E+01	1.9964E+02	.0000E+00	1.2092E-04	4.4822E-03	.0000E+00	-2.6560E-03
2440	1.2960E+03	2.5000E+02	1.4000E+02	2.6206E+01	2.0127E+02	.0000E+00	2.7218E-04	4.5241E-03	.0000E+00	-2.4137E-03
2450	1.3050E+03	2.7500E+02	1.6250E+02	8.9122E+01	2.0201E+02	.0000E+00	4.2763E-04	4.5636E-03	.0000E+00	-2.1664E-03
2460	1.3140E+03	3.0000E+02	1.8500E+02	1.5330E+02	2.0207E+02	.0000E+00	5.8652E-04	4.6012E-03	.0000E+00	-1.9147E-03
2470	1.3230E+03	3.2500E+02	2.0750E+02	2.1827E+02	2.0170E+02	.0000E+00	7.4797E-04	4.6368E-03	.0000E+00	-1.6598E-03
2480	1.3320E+03	3.5000E+02	2.3000E+02	2.8416E+02	2.0084E+02	.0000E+00	9.1225E-04	4.6704E-03	.0000E+00	-1.4014E-03
2490	1.3410E+03	3.7500E+02	2.5250E+02	3.5078E+02	1.9958E+02	.0000E+00	1.0790E-03	4.7026E-03	.0000E+00	-1.1395E-03
2500	1.3500E+03	4.0000E+02	2.7500E+02	4.1826E+02	1.9786E+02	.0000E+00	1.2486E-03	4.7335E-03	.0000E+00	-8.7392E-04
2510	1.3590E+03	4.2500E+02	2.9750E+02	4.8635E+02	1.9581E+02	.0000E+00	1.4204E-03	4.7628E-03	.0000E+00	-6.0506E-04
2520	1.3680E+03	4.5000E+02	3.2000E+02	5.5511E+02	1.9340E+02	.0000E+00	1.5948E-03	4.7906E-03	.0000E+00	-3.3277E-04
2530	1.3770E+03	4.7500E+02	3.4250E+02	6.2445E+02	1.9068E+02	.0000E+00	1.7714E-03	4.8171E-03	.0000E+00	-5.7225E-05
2540	1.3860E+03	5.0000E+02	3.6500E+02	6.9457E+02	1.8754E+02	.0000E+00	1.9509E-03	4.8421E-03	.0000E+00	2.2208E-04
2550	1.3950E+03	5.2500E+02	3.8750E+02	7.6524E+02	1.8410E+02	.0000E+00	2.1326E-03	4.8663E-03	.0000E+00	5.0467E-04
2560	1.4040E+03	5.5000E+02	4.1000E+02	8.3649E+02	1.8035E+02	.0000E+00	2.3168E-03	4.8893E-03	.0000E+00	7.9085E-04
2570	1.4130E+03	5.7500E+02	4.3250E+02	9.0823E+02	1.7634E+02	.0000E+00	2.5033E-03	4.9115E-03	.0000E+00	1.0804E-03
2580	1.4220E+03	6.0000E+02	4.5500E+02	9.8237E+02	1.7103E+02	.0000E+00	2.6969E-03	4.9374E-03	.0000E+00	1.3779E-03
2590	1.4310E+03	6.2500E+02	4.7750E+02	1.0598E+03	1.6394E+02	.0000E+00	2.9002E-03	4.9694E-03	.0000E+00	1.6861E-03
2600	1.4400E+03	6.5000E+02	5.0000E+02	1.1413E+03	1.5469E+02	.0000E+00	3.1155E-03	5.0108E-03	.0000E+00	2.0073E-03
2610	1.4490E+03	6.2500E+02	4.7750E+02	1.0713E+03	1.5776E+02	.0000E+00	2.9301E-03	4.9994E-03	.0000E+00	1.7160E-03
2620	1.4580E+03	6.0000E+02	4.5500E+02	9.9929E+02	1.6192E+02	.0000E+00	2.7406E-03	4.9811E-03	.0000E+00	1.4216E-03
2630	1.4670E+03	5.7500E+02	4.3250E+02	9.2735E+02	1.6604E+02	.0000E+00	2.5524E-03	4.9605E-03	.0000E+00	1.1294E-03
2640	1.4760E+03	5.5000E+02	4.1000E+02	8.5587E+02	1.6991E+02	.0000E+00	2.3664E-03	4.9389E-03	.0000E+00	8.4044E-04
2650	1.4850E+03	5.2500E+02	3.8750E+02	7.8486E+02	1.7353E+02	.0000E+00	2.1827E-03	4.9164E-03	.0000E+00	5.5477E-04
2660	1.4940E+03	5.0000E+02	3.6500E+02	7.1443E+02	1.7684E+02	.0000E+00	2.0014E-03	4.8926E-03	.0000E+00	2.7264E-04
2670	1.5030E+03	4.7500E+02	3.4250E+02	6.4453E+02	1.7987E+02	.0000E+00	1.8224E-03	4.8681E-03	.0000E+00	-6.2381E-06
2680	1.5120E+03	4.5000E+02	3.2000E+02	5.7539E+02	1.8248E+02	.0000E+00	1.6462E-03	4.8420E-03	.0000E+00	-2.8140E-04
2690	1.5210E+03	4.2500E+02	2.9750E+02	5.0682E+02	1.8479E+02	.0000E+00	1.4722E-03	4.8146E-03	.0000E+00	-5.5332E-04
2700	1.5300E+03	4.0000E+02	2.7500E+02	4.3892E+02	1.8673E+02	.0000E+00	1.3007E-03	4.7856E-03	.0000E+00	-8.2184E-04
2710	1.5390E+03	3.7500E+02	2.5250E+02	3.7162E+02	1.8836E+02	.0000E+00	1.1314E-03	4.7550E-03	.0000E+00	-1.0871E-03
2720	1.5480E+03	3.5000E+02	2.3000E+02	3.0516E+02	1.8953E+02	.0000E+00	9.6493E-04	4.7231E-03	.0000E+00	-1.3487E-03
2730	1.5570E+03	3.2500E+02	2.0750E+02	2.3943E+02	1.9031E+02	.0000E+00	8.0090E-04	4.6898E-03	.0000E+00	-1.6068E-03
2740	1.5660E+03	3.0000E+02	1.8500E+02	1.7459E+02	1.9061E+02	.0000E+00	6.3967E-04	4.6544E-03	.0000E+00	-1.8616E-03
2750	**1.5750E+03**	**2.7500E+02**	**1.6250E+02**	**1.1055E+02**	**1.9048E+02**	**.0000E+00**	**4.8098E-04**	**4.6170E-03**	**.0000E+00**	**-2.1131E-03**
2760	1.5840E+03	2.5000E+02	1.4000E+02	4.7738E+01	1.8968E+02	.0000E+00	3.2567E-04	4.5776E-03	.0000E+00	-2.3603E-03
2770	1.5930E+03	2.2500E+02	1.1750E+02	-1.3441E+01	1.8801E+02	.0000E+00	1.7446E-04	4.5357E-03	.0000E+00	-2.6024E-03
2780	1.6020E+03	2.0000E+02	9.5000E+01	-7.3970E+01	1.8598E+02	.0000E+00	2.5370E-05	4.4916E-03	.0000E+00	-2.8419E-03
2790	1.6110E+03	1.7500E+02	7.2500E+01	-1.3364E+02	1.8350E+02	.0000E+00	-1.2115E-04	4.4446E-03	.0000E+00	-3.0794E-03
2800	1.6200E+03	1.5000E+02	5.0000E+01	-1.9267E+02	1.8067E+02	.0000E+00	-2.6562E-04	4.3954E-03	.0000E+00	-3.3141E-03
2810	1.6290E+03	1.7500E+02	7.2500E+01	-1.3364E+02	1.8350E+02	.0000E+00	-1.2115E-04	4.4446E-03	.0000E+00	-3.0794E-03
2820	1.6380E+03	2.0000E+02	9.5000E+01	-7.3970E+01	1.8598E+02	.0000E+00	2.5370E-05	4.4916E-03	.0000E+00	-2.8419E-03
2830	1.6470E+03	2.2500E+02	1.1750E+02	-1.3441E+01	1.8801E+02	.0000E+00	1.7446E-04	4.5357E-03	.0000E+00	-2.6024E-03
2840	1.6560E+03	2.5000E+02	1.4000E+02	4.7738E+01	1.8968E+02	.0000E+00	3.2567E-04	4.5776E-03	.0000E+00	-2.3603E-03
2850	1.6650E+03	2.7500E+02	1.6250E+02	1.1055E+02	1.9048E+02	.0000E+00	4.8098E-04	4.6170E-03	.0000E+00	-2.1131E-03
2860	1.6740E+03	3.0000E+02	1.8500E+02	1.7459E+02	1.9061E+02	.0000E+00	6.3967E-04	4.6544E-03	.0000E+00	-1.8616E-03
2870	1.6830E+03	3.2500E+02	2.0750E+02	2.3943E+02	1.9031E+02	.0000E+00	8.0090E-04	4.6898E-03	.0000E+00	-1.6068E-03

2880	1.6920E+03	3.5000E+02	2.3000E+02	3.0516E+02	1.8953E+02	.0000E+00	9.6493E-04	4.7231E-03	.0000E+00	-1.3487E-03
2890	1.7010E+03	3.7500E+02	2.5250E+02	3.7162E+02	1.8836E+02	.0000E+00	1.1314E-03	4.7550E-03	.0000E+00	-1.0871E-03
2900	1.7100E+03	4.0000E+02	2.7500E+02	4.3892E+02	1.8673E+02	.0000E+00	1.3007E-03	4.7856E-03	.0000E+00	-8.2184E-04
2910	1.7190E+03	4.2500E+02	2.9750E+02	5.0682E+02	1.8479E+02	.0000E+00	1.4722E-03	4.8146E-03	.0000E+00	-5.5332E-04
2920	1.7280E+03	4.5000E+02	3.2000E+02	5.7539E+02	1.8248E+02	.0000E+00	1.6462E-03	4.8420E-03	.0000E+00	-2.8140E-04
2930	1.7370E+03	4.7500E+02	3.4250E+02	6.4453E+02	1.7987E+02	.0000E+00	1.8224E-03	4.8681E-03	.0000E+00	-6.2381E-06
2940	1.7460E+03	5.0000E+02	3.6500E+02	7.1443E+02	1.7684E+02	.0000E+00	2.0014E-03	4.8926E-03	.0000E+00	2.7264E-04
2950	1.7550E+03	5.2500E+02	3.8750E+02	7.8486E+02	1.7353E+02	.0000E+00	2.1827E-03	4.9164E-03	.0000E+00	5.5477E-04
2960	1.7640E+03	5.5000E+02	4.1000E+02	8.5587E+02	1.6991E+02	.0000E+00	2.3664E-03	4.9389E-03	.0000E+00	8.4044E-04
2970	1.7730E+03	5.7500E+02	4.3250E+02	9.2735E+02	1.6604E+02	.0000E+00	2.5524E-03	4.9605E-03	.0000E+00	1.1294E-03
2980	1.7820E+03	6.0000E+02	4.5500E+02	1.0001E+03	1.6148E+02	.0000E+00	2.7426E-03	4.9831E-03	.0000E+00	1.4236E-03
2990	1.7910E+03	6.2500E+02	4.7750E+02	1.0764E+03	1.5500E+02	.0000E+00	2.9430E-03	5.0123E-03	.0000E+00	1.7289E-03
3000	1.8000E+03	6.5000E+02	5.0000E+02	1.1559E+03	1.4681E+02	.0000E+00	3.1534E-03	5.0486E-03	.0000E+00	2.0451E-03
3010	1.8090E+03	6.2500E+02	4.7750E+02	1.0852E+03	1.5025E+02	.0000E+00	2.9660E-03	5.0353E-03	.0000E+00	1.7519E-03
3020	1.8180E+03	6.0000E+02	4.5500E+02	1.0132E+03	1.5445E+02	.0000E+00	2.7763E-03	5.0168E-03	.0000E+00	1.4573E-03
3030	1.8270E+03	5.7500E+02	4.3250E+02	9.4143E+02	1.5846E+02	.0000E+00	2.5885E-03	4.9967E-03	.0000E+00	1.1656E-03
3040	1.8360E+03	5.5000E+02	4.1000E+02	8.7014E+02	1.6223E+02	.0000E+00	2.4030E-03	4.9755E-03	.0000E+00	8.7698E-041
3050	1.8450E+03	5.2500E+02	3.8750E+02	7.9932E+02	1.6575E+02	.0000E+00	2.2196E-03	4.9533E-03	.0000E+00	5.9167E-04
3060	1.8540E+03	5.0000E+02	3.6500E+02	7.2905E+02	1.6897E+02	.0000E+00	2.0387E-03	4.9299E-03	.0000E+00	3.0989E-04
3070	1.8630E+03	4.7500E+02	3.4250E+02	6.5931E+02	1.7191E+02	.0000E+00	1.8600E-03	4.9056E-03	.0000E+00	3.1327E-05
3080	1.8720E+03	4.5000E+02	3.2000E+02	5.9033E+02	1.7444E+02	.0000E+00	1.6840E-03	4.8798E-03	.0000E+00	-2.4355E-04
3090	1.8810E+03	4.2500E+02	2.9750E+02	5.2190E+02	1.7667E+02	.0000E+00	1.5103E-03	4.8527E-03	.0000E+00	-5.1520E-04
3100	1.8900E+03	4.0000E+02	2.7500E+02	4.5413E+02	1.7854E+02	.0000E+00	1.3390E-03	4.8239E-03	.0000E+00	-7.8347E-04
3110	1.8990E+03	3.7500E+02	2.5250E+02	3.8697E+02	1.8009E+02	.0000E+00	1.1700E-03	4.7936E-03	.0000E+00	-1.0485E-03
3120	1.9080E+03	3.5000E+02	2.3000E+02	3.2062E+02	1.8120E+02	.0000E+00	1.0037E-03	4.7619E-03	.0000E+00	-1.3099E-03
3130	1.9170E+03	3.2500E+02	2.0750E+02	2.5500E+02	1.8192E+02	.0000E+00	8.3990E-04	4.7288E-03	.0000E+00	-1.5678E-03
3140	1.9260E+03	3.0000E+02	1.8500E+02	1.9026E+02	1.8217E+02	.0000E+00	6.7882E-04	4.6935E-03	.0000E+00	-1.8224E-03
3150	1.9350E+03	2.7500E+02	1.6250E+02	1.2632E+02	1.8198E+02	.0000E+00	5.2028E-04	4.6563E-03	.0000E+00	-2.0738E-03
3160	1.9440E+03	2.5000E+02	1.4000E+02	6.3590E+01	1.8114E+02	.0000E+00	3.6508E-04	4.6170E-03	.0000E+00	-2.3208E-03
3170	1.9530E+03	2.2500E+02	1.1750E+02	2.4649E+00	1.7944E+02	.0000E+00	2.1391E-04	4.5751E-03	.0000E+00	-2.5630E-03
3180	1.9620E+03	2.0000E+02	9.5000E+01	-5.8010E+01	1.7739E+02	.0000E+00	6.4858E-05	4.5311E-03	.0000E+00	-2.8024E-03
3190	1.9710E+03	1.7500E+02	7.2500E+01	-1.1762E+02	1.7487E+02	.0000E+00	-8.1627E-05	4.4841E-03	.0000E+00	-3.0399E-03
3200	1.9800E+03	1.5000E+02	5.0000E+01	-1.7660E+02	1.7202E+02	.0000E+00	-2.2606E-04	4.4350E-03	.0000E+00	-3.2745E-03

```
    ************************************
    *                                  *
    *   F I D E P 2 - VERSION 6        *
    *                                  *
    ************************************

  ************ PROBLEM TITLE ************

Uniaxial Test of [90] Ply Damage Model

  ************ GEOMETRY TYPE ************

     1-D Laminate Model

  ************ LOADING TYPE ************

      Strain Control

  ********* LOADING HISTORY ************

  POINTS IN HISTORY  8

      Step          Time      Temperature  Axial Strain
     .0000E+00    .0000E+00   2.3000E+01    .0000E+00
    1.0000E+03   3.9000E+01   2.3000E+01   3.2500E-03
    2.0000E+03   7.8000E+01   2.3000E+01    .0000E+00
    3.0000E+03   1.5660E+02   2.3000E+01   6.5500E-03
    4.0000E+03   2.3630E+02   2.3000E+01    .0000E+00
    5.0000E+03   3.8530E+02   2.3000E+01   1.2500E-02
    6.0000E+03   5.3530E+02   2.3000E+01    .0000E+00
    7.0000E+03   7.1530E+02   2.3000E+01   1.5000E-02

  ********* GEOMETRY INFORMATION  ***********

  Number of Cells  1

       For Cell Number : 1

            Material Number :  5
            Volume Fraction :  1.0
            Nodes in cell   :  2

  ********** OUTPUT INFORMATION  ************

  Output at Interface for Material:  1

  ********** MATERIAL INFORMATION  ************

  Material for Cell Number :  1

 Directional B-P Theory with [90] Ply Damage Model of Neu

 Constitutive model: Bodner-Partom with Directional Hardening

  ---------- MATERIAL PROPERTIES  ----------

     T(C)     E(GPa)     NU     CTE(1E-6/C)
   2.3000E+01   1.3300E+02   1.9000E-01   6.2279E+00
   2.6000E+02   1.2800E+02   1.9000E-01   7.2557E+00
   4.8200E+02   1.1900E+02   1.9000E-01   8.2184E+00
   5.3800E+02   1.1500E+02   1.8000E-01   8.4493E+00
   5.9300E+02   1.1200E+02   1.8000E-01   8.6577E+00
   6.5000E+02   1.0500E+02   1.7000E-01   8.8874E+00
   8.1500E+02   5.0000E+01   1.7000E-01   9.4902E+00
   9.0000E+02   2.0000E+01   1.7000E-01   9.7787E+00

  Reference Temperature =  23.0
  ----------------------------------------

      T(C)        N     Z0=Z2(1/S)   Z3(MPa)    M2(1/MPa)
   2.3000E+01   4.8000E+00   1.5500E+03   1.0000E+02   3.5000E-01
   2.6000E+02   3.5000E+00   1.3000E+03   3.0000E+02   3.5000E-01
   3.1500E+02   3.0540E+00   1.2504E+03   3.9000E+02   1.5020E+00
   3.6500E+02   2.6490E+00   1.2054E+03   5.0000E+02   2.5490E+00
   4.1500E+02   2.2430E+00   1.1604E+03   6.6000E+02   3.5970E+00
   4.6500E+02   1.8380E+00   1.1153E+03   9.6000E+02   4.6440E+00
   4.8200E+02   1.7000E+00   1.1000E+03   1.1000E+03   5.0000E+00
   5.0000E+02   1.5000E+00   1.0893E+03   1.3000E+03   5.7630E+00
   5.2500E+02   1.2800E+00   1.0744E+03   1.6700E+03   6.8220E+00
   5.5000E+02   1.1000E+00   1.0595E+03   2.1000E+03   7.8810E+00
   5.7500E+02   9.7000E-01   1.0446E+03   2.6000E+03   8.9410E+00
   6.0000E+02   8.2000E-01   1.0298E+03   3.7000E+03   1.0000E+01
```

```
 6.5000E+02   7.4000E-01   1.0000E+03   3.8000E+03   1.0000E+01
 7.6000E+02   5.8000E-01   6.0000E+02   4.0000E+03   1.5000E+01
 8.1500E+02   5.5000E-01   3.0000E+02   4.1000E+03   3.0000E+01
 9.0000E+02   5.5000E-01   3.0000E+02   4.3000E+03   3.0000E+01
 ----------------------------------------

    A1=A2       M1         Z1       R1=R2        DO
-9999.0 .0 1600.0 3.0 10000.0
 ----------------------------------------

    Temp        Sm
 2.3000E+01   1.9000E+02
 2.6000E+02   1.3000E+02
 4.8200E+02   7.0000E+01
 5.3800E+02   5.0000E+01
 5.9300E+02   3.6000E+01
 6.5000E+02   1.7000E+01
 8.1500E+02    .0000E+00
 ----------------------------------------

    scho      scl       m     theta      Dstar     beta    Dch
80.0 .0 1.0 100.0 .61 5.000000000000000E-02 .5
 ----------------------------------------

 -------------------- OUTPUT --------------------

   STEP     TIME        TEMPERATURE   SZ-APP        SZ-LAM1       SZ-LAM2       SZ-LAM3         ETOT
     1    3.9000E-02   2.3000E+01    4.3225E-01    4.3225E-01    .0000E+00     .0000E+00     3.2500E-06
    50    1.9500E+00   2.3000E+01    2.1613E+01    2.1613E+01    .0000E+00     .0000E+00     1.6250E-04
   100    3.9000E+00   2.3000E+01    4.3225E+01    4.3225E+01    .0000E+00     .0000E+00     3.2500E-04
   150    5.8500E+00   2.3000E+01    6.4837E+01    6.4837E+01    .0000E+00     .0000E+00     4.8750E-04
   200    7.8000E+00   2.3000E+01    8.6450E+01    8.6450E+01    .0000E+00     .0000E+00     6.5000E-04
   250    9.7500E+00   2.3000E+01    1.0806E+02    1.0806E+02    .0000E+00     .0000E+00     8.1250E-04
   300    1.1700E+01   2.3000E+01    1.2967E+02    1.2967E+02    .0000E+00     .0000E+00     9.7500E-04
   350    1.3650E+01   2.3000E+01    1.5129E+02    1.5129E+02    .0000E+00     .0000E+00     1.1375E-03
   400    1.5600E+01   2.3000E+01    1.7290E+02    1.7290E+02    .0000E+00     .0000E+00     1.3000E-03
   450    1.7550E+01   2.3000E+01    1.9451E+02    1.9451E+02    .0000E+00     .0000E+00     1.4625E-03
   500    1.9500E+01   2.3000E+01    2.1613E+02    2.1613E+02    .0000E+00     .0000E+00     1.6250E-03
   550    2.1450E+01   2.3000E+01    2.3774E+02    2.3774E+02    .0000E+00     .0000E+00     1.7875E-03
   600    2.3400E+01   2.3000E+01    2.5935E+02    2.5935E+02    .0000E+00     .0000E+00     1.9500E-03
   650    2.5350E+01   2.3000E+01    2.7058E+02    2.7058E+02    .0000E+00     .0000E+00     2.1125E-03
   700    2.7300E+01   2.3000E+01    2.7215E+02    2.7215E+02    .0000E+00     .0000E+00     2.2750E-03
   750    2.9250E+01   2.3000E+01    2.7460E+02    2.7460E+02    .0000E+00     .0000E+00     2.4375E-03
   800    3.1200E+01   2.3000E+01    2.7768E+02    2.7768E+02    .0000E+00     .0000E+00     2.6000E-03
   850    3.3150E+01   2.3000E+01    2.8120E+02    2.8120E+02    .0000E+00     .0000E+00     2.7625E-03
   900    3.5100E+01   2.3000E+01    2.8506E+02    2.8506E+02    .0000E+00     .0000E+00     2.9250E-03
   950    3.7050E+01   2.3000E+01    2.8918E+02    2.8918E+02    .0000E+00     .0000E+00     3.0875E-03
  1000    3.9000E+01   2.3000E+01    2.9350E+02    2.9350E+02    .0000E+00     .0000E+00     3.2500E-03
  1050   4.0950E+01    2.3000E+01    2.7863E+02    2.7863E+02    .0000E+00     .0000E+00     3.0875E-03
  1100   4.2900E+01    2.3000E+01    2.6397E+02    2.6397E+02    .0000E+00     .0000E+00     2.9250E-03
  1150   4.4850E+01    2.3000E+01    2.4931E+02    2.4931E+02    .0000E+00     .0000E+00     2.7625E-03
  1200   4.6800E+01    2.3000E+01    2.3464E+02    2.3464E+02    .0000E+00     .0000E+00     2.6000E-03
  1250   4.8750E+01    2.3000E+01    2.1998E+02    2.1998E+02    .0000E+00     .0000E+00     2.4375E-03
  1300    5.0700E+01   2.3000E+01    2.0531E+02    2.0531E+02    .0000E+00     .0000E+00     2.2750E-03
  1350    5.2650E+01   2.3000E+01    1.9065E+02    1.9065E+02    .0000E+00     .0000E+00     2.1125E-03
  1400    5.4600E+01   2.3000E+01    1.7599E+02    1.7599E+02    .0000E+00     .0000E+00     1.9500E-03
  1450    5.6550E+01   2.3000E+01    1.6134E+02    1.6134E+02    .0000E+00     .0000E+00     1.7875E-03
  1500    5.8500E+01   2.3000E+01    1.4669E+02    1.4669E+02    .0000E+00     .0000E+00     1.6250E-03
  1550    6.0450E+01   2.3000E+01    1.3207E+02    1.3207E+02    .0000E+00     .0000E+00     1.4625E-03
  1600    6.2400E+01   2.3000E+01    1.1747E+02    1.1747E+02    .0000E+00     .0000E+00     1.3000E-03
  1650    6.4350E+01   2.3000E+01    1.0293E+02    1.0293E+02    .0000E+00     .0000E+00     1.1375E-03
  1700    6.6300E+01   2.3000E+01    8.8477E+01    8.8477E+01    .0000E+00     .0000E+00     9.7500E-04
  1750    6.8250E+01   2.3000E+01    7.4146E+01    7.4146E+01    .0000E+00     .0000E+00     8.1250E-04
  1800    7.0200E+01   2.3000E+01    5.9963E+01    5.9963E+01    .0000E+00     .0000E+00     6.5000E-04
  1850    7.2150E+01   2.3000E+01    4.5880E+01    4.5880E+01    .0000E+00     .0000E+00     4.8750E-04
  1900    7.4100E+01   2.3000E+01    3.1668E+01    3.1668E+01    .0000E+00     .0000E+00     3.2500E-04
  1950    7.6050E+01   2.3000E+01    1.6741E+01    1.6741E+01    .0000E+00     .0000E+00     1.6250E-04
  2000    7.8000E+01   2.3000E+01     .0000E+00     .0000E+00    .0000E+00     .0000E+00      .0000E+00
  2050    8.1930E+01   2.3000E+01    3.1968E+01    3.1968E+01    .0000E+00     .0000E+00     3.2750E-04
  2100    8.5860E+01   2.3000E+01    6.0447E+01    6.0447E+01    .0000E+00     .0000E+00     6.5500E-04
  2150    8.9790E+01   2.3000E+01    8.9162E+01    8.9162E+01    .0000E+00     .0000E+00     9.8250E-04
  2200    9.3720E+01   2.3000E+01    1.1838E+02    1.1838E+02    .0000E+00     .0000E+00     1.3100E-03
  2250    9.7650E+01   2.3000E+01    1.4782E+02    1.4782E+02    .0000E+00     .0000E+00     1.6375E-03
  2300    1.0158E+02   2.3000E+01    1.7735E+02    1.7735E+02    .0000E+00     .0000E+00     1.9650E-03
  2350    1.0551E+02   2.3000E+01    2.0689E+02    2.0689E+02    .0000E+00     .0000E+00     2.2925E-03
  2400    1.0944E+02   2.3000E+01    2.3645E+02    2.3645E+02    .0000E+00     .0000E+00     2.6200E-03
  2450    1.1337E+02   2.3000E+01    2.6600E+02    2.6600E+02    .0000E+00     .0000E+00     2.9475E-03
  2500    1.1730E+02   2.3000E+01    2.9429E+02    2.9429E+02    .0000E+00     .0000E+00     3.2750E-03
  2550    1.2123E+02   2.3000E+01    3.0351E+02    3.0351E+02    .0000E+00     .0000E+00     3.6025E-03
  2600    1.2516E+02   2.3000E+01    3.1319E+02    3.1319E+02    .0000E+00     .0000E+00     3.9300E-03
  2650    1.2909E+02   2.3000E+01    3.2322E+02    3.2322E+02    .0000E+00     .0000E+00     4.2575E-03
  2700    1.3302E+02   2.3000E+01    3.3354E+02    3.3354E+02    .0000E+00     .0000E+00     4.5850E-03
  2750    1.3695E+02   2.3000E+01    3.4412E+02    3.4412E+02    .0000E+00     .0000E+00     4.9125E-03
  2800    1.4088E+02   2.3000E+01    3.5494E+02    3.5494E+02    .0000E+00     .0000E+00     5.2400E-03
  2850    1.4481E+02   2.3000E+01    3.6639E+02    3.6639E+02    .0000E+00     .0000E+00     5.5675E-03
  2900    1.4874E+02   2.3000E+01    3.7854E+02    3.7854E+02    .0000E+00     .0000E+00     5.8950E-03
```

2950	1.5267E+02	2.3000E+01	3.9074E+02	3.9074E+02	.0000E+00	.0000E+00	6.2225E-03
3000	1.5660E+02	2.3000E+01	4.0303E+02	4.0303E+02	.0000E+00	.0000E+00	6.5500E-03
3050	1.6059E+02	2.3000E+01	3.8273E+02	3.8273E+02	.0000E+00	.0000E+00	6.2225E-03
3100	1.6457E+02	2.3000E+01	3.6259E+02	3.6259E+02	.0000E+00	.0000E+00	5.8950E-03
3150	1.6856E+02	2.3000E+01	3.4245E+02	3.4245E+02	.0000E+00	.0000E+00	5.5675E-03
3200	1.7254E+02	2.3000E+01	3.2230E+02	3.2230E+02	.0000E+00	.0000E+00	5.2400E-03
3250	1.7653E+02	2.3000E+01	3.0216E+02	3.0216E+02	.0000E+00	.0000E+00	4.9125E-03
3300	1.8051E+02	2.3000E+01	2.8201E+02	2.8201E+02	.0000E+00	.0000E+00	4.5850E-03
3350	1.8450E+02	2.3000E+01	2.6187E+02	2.6187E+02	.0000E+00	.0000E+00	4.2575E-03
3400	1.8848E+02	2.3000E+01	2.4173E+02	2.4173E+02	.0000E+00	.0000E+00	3.9300E-03
3450	1.9247E+02	2.3000E+01	2.2159E+02	2.2159E+02	.0000E+00	.0000E+00	3.6025E-03
3500	1.9645E+02	2.3000E+01	2.0145E+02	2.0145E+02	.0000E+00	.0000E+00	3.2750E-03
3550	2.0044E+02	2.3000E+01	1.8132E+02	1.8132E+02	.0000E+00	.0000E+00	2.9475E-03
3600	2.0442E+02	2.3000E+01	1.6121E+02	1.6121E+02	.0000E+00	.0000E+00	2.6200E-03
3650	2.0841E+02	2.3000E+01	1.4115E+02	1.4115E+02	.0000E+00	.0000E+00	2.2925E-03
3700	2.1239E+02	2.3000E+01	1.2118E+02	1.2118E+02	.0000E+00	.0000E+00	1.9650E-03
3750	2.1638E+02	2.3000E+01	1.0143E+02	1.0143E+02	.0000E+00	.0000E+00	1.6375E-03
3800	2.2036E+02	2.3000E+01	8.2069E+01	8.2069E+01	.0000E+00	.0000E+00	1.3100E-03
3850	2.2435E+02	2.3000E+01	6.3235E+01	6.3235E+01	.0000E+00	.0000E+00	9.8250E-04
3900	2.2833E+02	2.3000E+01	4.4732E+01	4.4732E+01	.0000E+00	.0000E+00	6.5500E-04
3950	2.3232E+02	2.3000E+01	2.5228E+01	2.5228E+01	.0000E+00	.0000E+00	3.2750E-04
4000	2.3630E+02	2.3000E+01	-8.3866E-14	-8.3866E-14	.0000E+00	.0000E+00	-8.6736E-19
4050	2.4375E+02	2.3000E+01	4.3210E+01	4.3210E+01	.0000E+00	.0000E+00	6.2500E-04
4100	2.5120E+02	2.3000E+01	7.8663E+01	7.8663E+01	.0000E+00	.0000E+00	1.2500E-03
4150	2.5865E+02	2.3000E+01	1.1575E+02	1.1575E+02	.0000E+00	.0000E+00	1.8750E-03
4200	2.6610E+02	2.3000E+01	1.5385E+02	1.5385E+02	.0000E+00	.0000E+00	2.5000E-03
4250	2.7355E+02	2.3000E+01	1.9223E+02	1.9223E+02	.0000E+00	.0000E+00	3.1250E-03
4300	2.8100E+02	2.3000E+01	2.3066E+02	2.3066E+02	.0000E+00	.0000E+00	3.7500E-03
4350	2.8845E+02	2.3000E+01	2.6910E+02	2.6910E+02	.0000E+00	.0000E+00	4.3750E-03
4400	2.9590E+02	2.3000E+01	3.0754E+02	3.0754E+02	.0000E+00	.0000E+00	5.0000E-03
4450	3.0335E+02	2.3000E+01	3.4598E+02	3.4598E+02	.0000E+00	.0000E+00	5.6250E-03
4500	3.1080E+02	2.3000E+01	3.8443E+02	3.8443E+02	.0000E+00	.0000E+00	6.2500E-03
4550	3.1825E+02	2.3000E+01	4.1542E+02	4.1542E+02	.0000E+00	.0000E+00	6.8750E-03
4600	3.2570E+02	2.3000E+01	4.3948E+02	4.3948E+02	.0000E+00	.0000E+00	7.5000E-03
4650	3.3315E+02	2.3000E+01	4.5917E+02	4.5917E+02	.0000E+00	.0000E+00	8.1250E-03
4700	3.4060E+02	2.3000E+01	4.6283E+02	4.6283E+02	.0000E+00	.0000E+00	8.7500E-03
4750	3.4805E+02	2.3000E+01	4.6591E+02	4.6591E+02	.0000E+00	.0000E+00	9.3750E-03
4800	3.5550E+02	2.3000E+01	4.6849E+02	4.6849E+02	.0000E+00	.0000E+00	1.0000E-02
4850	3.6295E+02	2.3000E+01	4.7063E+02	4.7063E+02	.0000E+00	.0000E+00	1.0625E-02
4900	3.7040E+02	2.3000E+01	4.7239E+02	4.7239E+02	.0000E+00	.0000E+00	1.1250E-02
4950	3.7785E+02	2.3000E+01	4.7382E+02	4.7382E+02	.0000E+00	.0000E+00	1.1875E-02
5000	3.8530E+02	2.3000E+01	4.7497E+02	4.7497E+02	.0000E+00	.0000E+00	1.2500E-02
5050	3.9280E+02	2.3000E+01	4.3770E+02	4.3770E+02	.0000E+00	.0000E+00	1.1875E-02
5100	4.0030E+02	2.3000E+01	4.0235E+02	4.0235E+02	.0000E+00	.0000E+00	1.1250E-02
5150	4.0780E+02	2.3000E+01	3.6700E+02	3.6700E+02	.0000E+00	.0000E+00	1.0625E-02
5200	4.1530E+02	2.3000E+01	3.3164E+02	3.3164E+02	.0000E+00	.0000E+00	1.0000E-02
5250	4.2280E+02	2.3000E+01	2.9629E+02	2.9629E+02	.0000E+00	.0000E+00	9.3750E-03
5300	4.3030E+02	2.3000E+01	2.6094E+02	2.6094E+02	.0000E+00	.0000E+00	8.7500E-03
5350	4.3780E+02	2.3000E+01	2.2559E+02	2.2559E+02	.0000E+00	.0000E+00	8.1250E-03
5400	4.4530E+02	2.3000E+01	1.9025E+02	1.9025E+02	.0000E+00	.0000E+00	7.5000E-03
5450	4.5280E+02	2.3000E+01	1.5497E+02	1.5497E+02	.0000E+00	.0000E+00	6.8750E-03
5500	4.6030E+02	2.3000E+01	1.1992E+02	1.1992E+02	.0000E+00	.0000E+00	6.2500E-03
5550	4.6780E+02	2.3000E+01	8.5673E+01	8.5673E+01	.0000E+00	.0000E+00	5.6250E-03
5600	4.7530E+02	2.3000E+01	5.3040E+01	5.3040E+01	.0000E+00	.0000E+00	5.0000E-03
5650	4.8280E+02	2.3000E+01	1.8491E+01	1.8491E+01	.0000E+00	.0000E+00	4.3750E-03
5700	4.9030E+02	2.3000E+01	-4.8889E+01	-4.8889E+01	.0000E+00	.0000E+00	3.7500E-03
5750	4.9780E+02	.3000E+01	-1.3448E+02	-1.3448E+02	.0000E+00	.0000E+00	3.1250E-03
5800	5.0530E+02	2.3000E+01	-2.1770E+02	-2.1770E+02	.0000E+00	.0000E+00	2.5000E-03
5850	5.1280E+02	2.3000E+01	-3.0083E+02	-3.0083E+02	.0000E+00	.0000E+00	1.8750E-03
5900	5.2030E+02	2.3000E+01	-3.8395E+02	-3.8395E+02	.0000E+00	.0000E+00	1.2500E-03
5950	5.2780E+02	2.3000E+01	-4.6708E+02	-4.6708E+02	.0000E+00	.0000E+00	6.2500E-04
6000	5.3530E+02	2.3000E+01	-5.5020E+02	-5.5020E+02	.0000E+00	.0000E+00	.0000E+00
6050	5.4430E+02	2.3000E+01	-4.5045E+02	-4.5045E+02	.0000E+00	.0000E+00	7.5000E-04
6100	5.5330E+02	2.3000E+01	-3.5070E+02	-3.5070E+02	.0000E+00	.0000E+00	1.5000E-03
6150	5.6230E+02	2.3000E+01	-2.5095E+02	-2.5095E+02	.0000E+00	.0000E+00	2.2500E-03
6200	5.7130E+02	2.3000E+01	-1.5116E+02	-1.5116E+02	.0000E+00	.0000E+00	3.0000E-03
6250	5.8030E+02	2.3000E+01	-4.9357E+01	-4.9357E+01	.0000E+00	.0000E+00	3.7500E-03
6300	5.8930E+02	2.3000E+01	2.6563E+01	2.6563E+01	.0000E+00	.0000E+00	4.5000E-03
6350	5.9830E+02	2.3000E+01	6.6092E+01	6.6092E+01	.0000E+00	.0000E+00	5.2500E-03
6400	6.0730E+02	2.3000E+01	1.0612E+02	1.0612E+02	.0000E+00	.0000E+00	6.0000E-03
6450	6.1630E+02	2.3000E+01	1.4794E+02	1.4794E+02	.0000E+00	.0000E+00	6.7500E-03
6500	6.2530E+02	2.3000E+01	1.9025E+02	1.9025E+02	.0000E+00	.0000E+00	7.5000E-03
6550	6.3430E+02	2.3000E+01	2.3266E+02	2.3266E+02	.0000E+00	.0000E+00	8.2500E-03
6600	6.4330E+02	2.3000E+01	2.7508E+02	2.7508E+02	.0000E+00	.0000E+00	9.0000E-03
6650	6.5230E+02	2.3000E+01	3.1750E+02	3.1750E+02	.0000E+00	.0000E+00	9.7500E-03
6700	6.6130E+02	2.3000E+01	3.5993E+02	3.5993E+02	.0000E+00	.0000E+00	1.0500E-02
6750	6.7030E+02	2.3000E+01	4.0235E+02	4.0235E+02	.0000E+00	.0000E+00	1.1250E-02
6800	6.7930E+02	2.3000E+01	4.4477E+02	4.4477E+02	.0000E+00	.0000E+00	1.2000E-02
6850	6.8830E+02	2.3000E+01	4.7534E+02	4.7534E+02	.0000E+00	.0000E+00	1.2750E-02
6900	6.9730E+02	2.3000E+01	4.7635E+02	4.7635E+02	.0000E+00	.0000E+00	1.3500E-02
6950	7.0630E+02	2.3000E+01	4.7710E+02	4.7710E+02	.0000E+00	.0000E+00	1.4250E-02
7000	7.1530E+02	2.3000E+01	4.7767E+02	4.7767E+02	.0000E+00	.0000E+00	1.5000E-02

```
    ************************************
    *                                  *
    *   F I D E P 2 - VERSION 6        *
    *                                  *
    ************************************

  ************ PROBLEM TITLE ************

Cyclic Test of [90] Ply Damage Model

  ************ GEOMETRY TYPE ************

     1-D Laminate Model

  ************ LOADING TYPE ************

      Strain Control

  ********* LOADING HISTORY ************

  POINTS IN HISTORY  8

      Step          Time      Temperature  Axial Strain
     .0000E+00    .0000E+00   2.3000E+01    .0000E+00
    1.8000E+02   1.8000E+02   2.3000E+01   1.5000E-02
    3.6000E+02   3.6000E+02   2.3000E+01  -1.5000E-02
    5.4000E+02   5.4000E+02   2.3000E+01   1.5000E-02
    7.2000E+02   7.2000E+02   2.3000E+01  -1.5000E-02
    9.0000E+02   9.0000E+02   2.3000E+01   1.5000E-02
    1.0800E+03   1.0800E+03   2.3000E+01  -1.5000E-02
    1.2600E+03   1.2600E+03   2.3000E+01   1.5000E-02

  ********* GEOMETRY INFORMATION  ***********

  Number of Cells  1

       For Cell Number : 1

            Material Number :  5
            Volume Fraction :  1.0
            Nodes in cell   :  2

  ********** OUTPUT INFORMATION  ************

  Output at Interface for Material:  1

  ********** MATERIAL INFORMATION  ************

  Material for Cell Number :  1

 Directional B-P Theory with [90] Ply Damage Model of Neu

 Constitutive model: Bodner-Partom with Directional Hardening

  ---------- MATERIAL PROPERTIES  ----------

     T(C)      E(GPa)      NU      CTE(1E-6/C)
   2.3000E+01   1.3300E+02   1.9000E-01   6.2279E+00
   2.6000E+02   1.2800E+02   1.9000E-01   7.2557E+00
   4.8200E+02   1.1900E+02   1.9000E-01   8.2184E+00
   5.3800E+02   1.1500E+02   1.8000E-01   8.4493E+00
   5.9300E+02   1.1200E+02   1.8000E-01   8.6577E+00
   6.5000E+02   1.0500E+02   1.7000E-01   8.8874E+00
   8.1500E+02   5.0000E+01   1.7000E-01   9.4902E+00
   9.0000E+02   2.0000E+01   1.7000E-01   9.7787E+00

  Reference Temperature =  23.0
  ----------------------------------------

      T(C)        N      Z0=Z2(1/S)    Z3(MPa)     M2(1/MPa)
   2.3000E+01   4.8000E+00   1.5500E+03   1.0000E+02   3.5000E-01
   2.6000E+02   3.5000E+00   1.3000E+03   3.0000E+02   3.5000E-01
   3.1500E+02   3.0540E+00   1.2504E+03   3.9000E+02   1.5020E+00
   3.6500E+02   2.6490E+00   1.2054E+03   5.0000E+02   2.5490E+00
   4.1500E+02   2.2430E+00   1.1604E+03   6.6000E+02   3.5970E+00
   4.6500E+02   1.8380E+00   1.1153E+03   9.6000E+02   4.6440E+00
   4.8200E+02   1.7000E+00   1.1000E+03   1.1000E+03   5.0000E+00
   5.0000E+02   1.5000E+00   1.0893E+03   1.3000E+03   5.7630E+00
   5.2500E+02   1.2800E+00   1.0744E+03   1.6700E+03   6.8220E+00
   5.5000E+02   1.1000E+00   1.0595E+03   2.1000E+03   7.8810E+00
   5.7500E+02   9.7000E-01   1.0446E+03   2.6000E+03   8.9410E+00
   6.0000E+02   8.2000E-01   1.0298E+03   3.7000E+03   1.0000E+01
   6.5000E+02   7.4000E-01   1.0000E+03   3.8000E+03   1.0000E+01
   7.6000E+02   5.8000E-01   6.0000E+02   4.0000E+03   1.5000E+01
```

```
  8.1500E+02   5.5000E-01   3.0000E+02   4.1000E+03   3.0000E+01
  9.0000E+02   5.5000E-01   3.0000E+02   4.3000E+03   3.0000E+01
 ----------------------------------------

    A1=A2       M1         Z1       R1=R2        DO
-9999.0 .0 1600.0 3.0 10000.0
 ----------------------------------------

    Temp        Sm
  2.3000E+01   1.9000E+02
  2.6000E+02   1.3000E+02
  4.8200E+02   7.0000E+01
  5.3800E+02   5.0000E+01
  5.9300E+02   3.6000E+01
  6.5000E+02   1.7000E+01
  8.1500E+02    .0000E+00
 ----------------------------------------

    scho      scl       m     theta      Dstar     beta    Dch
80.0 .0 1.0 100.0 .61 5.000000000000000E-02 .5
 ----------------------------------------

 -------------------- OUTPUT -------------------
```

STEP	TIME	TEMPERATURE	SZ-APP	SZ-LAM1	SZ-LAM2	SZ-LAM3	ETOT
1	1.0000E+00	2.3000E+01	1.1083E+01	1.1083E+01	.0000E+00	.0000E+00	8.3333E-05
10	1.0000E+01	2.3000E+01	1.1083E+02	1.1083E+02	.0000E+00	.0000E+00	8.3333E-04
20	2.0000E+01	2.3000E+01	2.2167E+02	2.2167E+02	.0000E+00	.0000E+00	1.6667E-03
30	3.0000E+01	2.3000E+01	2.7983E+02	2.7983E+02	.0000E+00	.0000E+00	2.5000E-03
40	4.0000E+01	2.3000E+01	2.9853E+02	2.9853E+02	.0000E+00	.0000E+00	3.3333E-03
50	5.0000E+01	2.3000E+01	3.2244E+02	3.2244E+02	.0000E+00	.0000E+00	4.1667E-03
60	6.0000E+01	2.3000E+01	3.4868E+02	3.4868E+02	.0000E+00	.0000E+00	5.0000E-03
70	7.0000E+01	2.3000E+01	3.7749E+02	3.7749E+02	.0000E+00	.0000E+00	5.8333E-03
80	8.0000E+01	2.3000E+01	4.0855E+02	4.0855E+02	.0000E+00	.0000E+00	6.6667E-03
90	9.0000E+01	2.3000E+01	4.4040E+02	4.4040E+02	.0000E+00	.0000E+00	7.5000E-03
100	1.0000E+02	2.3000E+01	4.6095E+02	4.6095E+02	.0000E+00	.0000E+00	8.3333E-03
110	1.1000E+02	2.3000E+01	4.6563E+02	4.6563E+02	.0000E+00	.0000E+00	9.1667E-03
120	1.2000E+02	2.3000E+01	4.6913E+02	4.6913E+02	.0000E+00	.0000E+00	1.0000E-02
130	1.3000E+02	2.3000E+01	4.7183E+02	4.7183E+02	.0000E+00	.0000E+00	1.0833E-02
140	1.4000E+02	2.3000E+01	4.7386E+02	4.7386E+02	.0000E+00	.0000E+00	1.1667E-02
150	1.5000E+02	2.3000E+01	4.7537E+02	4.7537E+02	.0000E+00	.0000E+00	1.2500E-02
160	1.6000E+02	2.3000E+01	4.7647E+02	4.7647E+02	.0000E+00	.0000E+00	1.3333E-02
170	1.7000E+02	2.3000E+01	4.7728E+02	4.7728E+02	.0000E+00	.0000E+00	1.4167E-02
180	1.8000E+02	2.3000E+01	4.7786E+02	4.7786E+02	.0000E+00	.0000E+00	1.5000E-02
190	1.9000E+02	2.3000E+01	3.7880E+02	3.7880E+02	.0000E+00	.0000E+00	1.3333E-02
200	2.0000E+02	2.3000E+01	2.8475E+02	2.8475E+02	.0000E+00	.0000E+00	1.1667E-02
210	2.1000E+02	2.3000E+01	1.9071E+02	1.9071E+02	.0000E+00	.0000E+00	1.0000E-02
220	2.2000E+02	2.3000E+01	9.7280E+01	9.7280E+01	.0000E+00	.0000E+00	8.3333E-03
230	2.3000E+02	2.3000E+01	3.7023E+00	3.7023E+00	.0000E+00	.0000E+00	6.6667E-03
240	2.4000E+02	2.3000E+01	-2.1555E+02	-2.1555E+02	.0000E+00	.0000E+00	5.0000E-03
250	2.5000E+02	2.3000E+01	-4.3722E+02	-4.3722E+02	.0000E+00	.0000E+00	3.3333E-03
260	2.6000E+02	2.3000E+01	-6.5889E+02	-6.5889E+02	.0000E+00	.0000E+00	1.6667E-03
270	2.7000E+02	2.3000E+01	-8.8055E+02	-8.8055E+02	.0000E+00	.0000E+00	1.7347E-18
280	2.8000E+02	2.3000E+01	-1.0284E+03	-1.0284E+03	.0000E+00	.0000E+00	-1.6667E-03
290	2.9000E+02	2.3000E+01	-1.0692E+03	-1.0692E+03	.0000E+00	.0000E+00	-3.3333E-03
300	3.0000E+02	2.3000E+01	-1.1062E+03	-1.1062E+03	.0000E+00	.0000E+00	-5.0000E-03
310	3.1000E+02	2.3000E+01	-1.1172E+03	-1.1172E+03	.0000E+00	.0000E+00	-6.6667E-03
320	3.2000E+02	2.3000E+01	-1.1221E+03	-1.1221E+03	.0000E+00	.0000E+00	-8.3333E-03
330	3.3000E+02	2.3000E+01	-1.0892E+03	-1.0892E+03	.0000E+00	.0000E+00	-1.0000E-02
340	3.4000E+02	2.3000E+01	-1.1354E+03	-1.1354E+03	.0000E+00	.0000E+00	-1.1667E-02
350	3.5000E+02	2.3000E+01	-1.1368E+03	-1.1368E+03	.0000E+00	.0000E+00	-1.3333E-02
360	3.6000E+02	2.3000E+01	-1.1374E+03	-1.1374E+03	.0000E+00	.0000E+00	-1.5000E-02
370	3.7000E+02	2.3000E+01	-8.8378E+02	-8.8378E+02	.0000E+00	.0000E+00	-1.3333E-02
380	3.8000E+02	2.3000E+01	-6.6211E+02	-6.6211E+02	.0000E+00	.0000E+00	-1.1667E-02
390	3.9000E+02	2.3000E+01	-4.4045E+02	-4.4045E+02	.0000E+00	.0000E+00	-1.0000E-02
400	4.0000E+02	2.3000E+01	-2.1878E+02	-2.1878E+02	.0000E+00	.0000E+00	-8.3333E-03
410	4.1000E+02	2.3000E+01	2.4065E+00	2.4065E+00	.0000E+00	.0000E+00	-6.6667E-03
420	4.2000E+02	2.3000E+01	9.6841E+01	9.6841E+01	.0000E+00	.0000E+00	-5.0000E-03
430	4.3000E+02	2.3000E+01	1.8936E+02	1.8936E+02	.0000E+00	.0000E+00	-3.3333E-03
440	4.4000E+02	2.3000E+01	2.8338E+02	2.8338E+02	.0000E+00	.0000E+00	-1.6667E-03
450	4.5000E+02	2.3000E+01	3.7743E+02	3.7743E+02	.0000E+00	.0000E+00	-2.6021E-18
460	4.6000E+02	2.3000E+01	4.3350E+02	4.3350E+02	.0000E+00	.0000E+00	1.6667E-03
470	4.7000E+02	2.3000E+01	4.3762E+02	4.3762E+02	.0000E+00	.0000E+00	3.3333E-03
480	4.8000E+02	2.3000E+01	4.6164E+02	4.6164E+02	.0000E+00	.0000E+00	5.0000E-03
490	4.9000E+02	2.3000E+01	4.7459E+02	4.7459E+02	.0000E+00	.0000E+00	6.6667E-03
500	5.0000E+02	2.3000E+01	4.5761E+02	4.5761E+02	.0000E+00	.0000E+00	8.3333E-03
510	5.1000E+02	2.3000E+01	4.7276E+02	4.7276E+02	.0000E+00	.0000E+00	1.0000E-02
520	5.2000E+02	2.3000E+01	4.8246E+02	4.8246E+02	.0000E+00	.0000E+00	1.1667E-02
530	5.3000E+02	2.3000E+01	4.7425E+02	4.7425E+02	.0000E+00	.0000E+00	1.3333E-02
540	5.4000E+02	2.3000E+01	4.7869E+02	4.7869E+02	.0000E+00	.0000E+00	1.5000E-02
550	5.5000E+02	2.3000E+01	3.7840E+02	3.7840E+02	.0000E+00	.0000E+00	1.3333E-02
560	5.6000E+02	2.3000E+01	2.8472E+02	2.8472E+02	.0000E+00	.0000E+00	1.1667E-02
570	5.7000E+02	2.3000E+01	1.9106E+02	1.9106E+02	.0000E+00	.0000E+00	1.0000E-02
580	5.8000E+02	2.3000E+01	9.7997E+01	9.7997E+01	.0000E+00	.0000E+00	8.3333E-03
590	5.9000E+02	2.3000E+01	5.2237E+00	5.2237E+00	.0000E+00	.0000E+00	6.6667E-03

600	6.0000E+02	2.3000E+01	-2.1291E+02	-2.1291E+02	.0000E+00	.0000E+00	5.0000E-03
610	6.1000E+02	2.3000E+01	-4.3458E+02	-4.3458E+02	.0000E+00	.0000E+00	3.3333E-03
620	6.2000E+02	2.3000E+01	-6.5625E+02	-6.5625E+02	.0000E+00	.0000E+00	1.6667E-03
630	6.3000E+02	2.3000E+01	-8.7791E+02	-8.7791E+02	.0000E+00	.0000E+00	1.7347E-18
640	6.4000E+02	2.3000E+01	-1.0205E+03	-1.0205E+03	.0000E+00	.0000E+00	-1.6667E-03
650	6.5000E+02	2.3000E+01	-1.0259E+03	-1.0259E+03	.0000E+00	.0000E+00	-3.3333E-03
660	6.6000E+02	2.3000E+01	-1.0618E+03	-1.0618E+03	.0000E+00	.0000E+00	-5.0000E-03
670	6.7000E+02	2.3000E+01	-1.1151E+03	-1.1151E+03	.0000E+00	.0000E+00	-6.6667E-03
680	6.8000E+02	2.3000E+01	-1.1310E+03	-1.1310E+03	.0000E+00	.0000E+00	-8.3333E-03
690	6.9000E+02	2.3000E+01	-1.1377E+03	-1.1377E+03	.0000E+00	.0000E+00	-1.0000E-02
700	7.0000E+02	2.3000E+01	-1.1403E+03	-1.1403E+03	.0000E+00	.0000E+00	-1.1667E-02
710	7.1000E+02	2.3000E+01	-1.1161E+03	-1.1161E+03	.0000E+00	.0000E+00	-1.3333E-02
720	7.2000E+02	2.3000E+01	-1.1160E+03	-1.1160E+03	.0000E+00	.0000E+00	-1.5000E-02
730	7.3000E+02	2.3000E+01	-8.9338E+02	-8.9338E+02	.0000E+00	.0000E+00	-1.3333E-02
740	7.4000E+02	2.3000E+01	-6.7171E+02	-6.7171E+02	.0000E+00	.0000E+00	-1.1667E-02
750	7.5000E+02	2.3000E+01	-4.5004E+02	-4.5004E+02	.0000E+00	.0000E+00	-1.0000E-02
760	7.6000E+02	2.3000E+01	-2.2838E+02	-2.2838E+02	.0000E+00	.0000E+00	-8.3333E-03
770	7.7000E+02	2.3000E+01	-5.9326E+00	-5.9326E+00	.0000E+00	.0000E+00	-6.6667E-03
780	7.8000E+02	2.3000E+01	9.2675E+01	9.2675E+01	.0000E+00	.0000E+00	-5.0000E-03
790	7.9000E+02	2.3000E+01	1.8455E+02	1.8455E+02	.0000E+00	.0000E+00	-3.3333E-03
800	8.0000E+02	2.3000E+01	2.7819E+02	2.7819E+02	.0000E+00	.0000E+00	-1.6667E-03
810	8.1000E+02	2.3000E+01	3.7186E+02	3.7186E+02	.0000E+00	.0000E+00	-1.7347E-18
820	8.2000E+02	2.3000E+01	4.3288E+02	4.3288E+02	.0000E+00	.0000E+00	1.6667E-03
830	8.3000E+02	2.3000E+01	4.3895E+02	4.3895E+02	.0000E+00	.0000E+00	3.3333E-03
840	8.4000E+02	2.3000E+01	4.5397E+02	4.5397E+02	.0000E+00	.0000E+00	5.0000E-03
850	8.5000E+02	2.3000E+01	4.7424E+02	4.7424E+02	.0000E+00	.0000E+00	6.6667E-03
860	8.6000E+02	2.3000E+01	4.6924E+02	4.6924E+02	.0000E+00	.0000E+00	8.3333E-03
870	8.7000E+02	2.3000E+01	4.8029E+02	4.8029E+02	.0000E+00	.0000E+00	1.0000E-02
880	8.8000E+02	2.3000E+01	4.7491E+02	4.7491E+02	.0000E+00	.0000E+00	1.1667E-02
890	8.9000E+02	2.3000E+01	4.7678E+02	4.7678E+02	.0000E+00	.0000E+00	1.3333E-02
900	9.0000E+02	2.3000E+01	4.7329E+02	4.7329E+02	.0000E+00	.0000E+00	1.5000E-02
910	9.1000E+02	2.3000E+01	3.7882E+02	3.7882E+02	.0000E+00	.0000E+00	1.3333E-02
920	9.2000E+02	2.3000E+01	2.8514E+02	2.8514E+02	.0000E+00	.0000E+00	1.1667E-02
930	9.3000E+02	2.3000E+01	1.9148E+02	1.9148E+02	.0000E+00	.0000E+00	1.0000E-02
940	9.4000E+02	2.3000E+01	9.8404E+01	9.8404E+01	.0000E+00	.0000E+00	8.3333E-03
950	9.5000E+02	2.3000E+01	5.7854E+00	5.7854E+00	.0000E+00	.0000E+00	6.6667E-03
960	9.6000E+02	2.3000E+01	-2.1192E+02	-2.1192E+02	.0000E+00	.0000E+00	5.0000E-03
970	9.7000E+02	2.3000E+01	-4.3359E+02	-4.3359E+02	.0000E+00	.0000E+00	3.3333E-03
980	9.8000E+02	2.3000E+01	-6.5526E+02	-6.5526E+02	.0000E+00	.0000E+00	1.6667E-03
990	9.9000E+02	2.3000E+01	-8.7693E+02	-8.7693E+02	.0000E+00	.0000E+00	1.7347E-18
1000	1.0000E+03	2.3000E+01	-1.0215E+03	-1.0215E+03	.0000E+00	.0000E+00	-1.6667E-03
1010	1.0100E+03	2.3000E+01	-1.0342E+03	-1.0342E+03	.0000E+00	.0000E+00	-3.3333E-03
1020	1.0200E+03	2.3000E+01	-1.1047E+03	-1.1047E+03	.0000E+00	.0000E+00	-5.0000E-03
1030	1.0300E+03	2.3000E+01	-1.0977E+03	-1.0977E+03	.0000E+00	.0000E+00	-6.6667E-03
1040	1.0400E+03	2.3000E+01	-1.1289E+03	-1.1289E+03	.0000E+00	.0000E+00	-8.3333E-03
1050	1.0500E+03	2.3000E+01	-1.1373E+03	-1.1373E+03	.0000E+00	.0000E+00	-1.0000E-02
1060	1.0600E+03	2.3000E+01	-1.1093E+03	-1.1093E+03	.0000E+00	.0000E+00	-1.1667E-02
1070	1.0700E+03	2.3000E+01	-1.1421E+03	-1.1421E+03	.0000E+00	.0000E+00	-1.3333E-02
1080	1.0800E+03	2.3000E+01	-1.1415E+03	-1.1415E+03	.0000E+00	.0000E+00	-1.5000E-02
1090	1.0900E+03	2.3000E+01	-8.6105E+02	-8.6105E+02	.0000E+00	.0000E+00	-1.3333E-02
1100	1.1000E+03	2.3000E+01	-6.3939E+02	-6.3939E+02	.0000E+00	.0000E+00	-1.1667E-02
1110	1.1100E+03	2.3000E+01	-4.1772E+02	-4.1772E+02	.0000E+00	.0000E+00	-1.0000E-02
1120	1.1200E+03	2.3000E+01	-1.9605E+02	-1.9605E+02	.0000E+00	.0000E+00	-8.3333E-03
1130	1.1300E+03	2.3000E+01	1.7691E+01	1.7691E+01	.0000E+00	.0000E+00	-6.6667E-03
1140	1.1400E+03	2.3000E+01	1.0562E+02	1.0562E+02	.0000E+00	.0000E+00	-5.0000E-03
1150	1.1500E+03	2.3000E+01	1.9820E+02	1.9820E+02	.0000E+00	.0000E+00	-3.3333E-03
1160	1.1600E+03	2.3000E+01	2.9185E+02	2.9185E+02	.0000E+00	.0000E+00	-1.6667E-03
1170	1.1700E+03	2.3000E+01	3.8552E+02	3.8552E+02	.0000E+00	.0000E+00	-1.7347E-18
1180	1.1800E+03	2.3000E+01	4.1541E+02	4.1541E+02	.0000E+00	.0000E+00	1.6667E-03
1190	1.1900E+03	2.3000E+01	4.4281E+02	4.4281E+02	.0000E+00	.0000E+00	3.3333E-03
1200	1.2000E+03	2.3000E+01	4.6735E+02	4.6735E+02	.0000E+00	.0000E+00	5.0000E-03
1210	1.2100E+03	2.3000E+01	4.7515E+02	4.7515E+02	.0000E+00	.0000E+00	6.6667E-03
1220	1.2200E+03	2.3000E+01	4.7886E+02	4.7886E+02	.0000E+00	.0000E+00	8.3333E-03
1230	1.2300E+03	2.3000E+01	4.6549E+02	4.6549E+02	.0000E+00	.0000E+00	1.0000E-02
1240	1.2400E+03	2.3000E+01	4.8146E+02	4.8146E+02	.0000E+00	.0000E+00	1.1667E-02
1250	1.2500E+03	2.3000E+01	4.7365E+02	4.7365E+02	.0000E+00	.0000E+00	1.3333E-02
1260	1.2600E+03	2.3000E+01	4.8108E+02	4.8108E+02	.0000E+00	.0000E+00	1.5000E-02

```
     ************************************
     *                                  *
     *   F I D E P 2 - VERSION 6        *
     *                                  *
     ************************************

  ************ PROBLEM TITLE ************
Loading and Unloading Test of [90] Ply Damage Model at 650C
  ************ GEOMETRY TYPE ************
     1-D Laminate Model
  ************ LOADING TYPE ************
      Strain Control
  ********* LOADING HISTORY ************
  POINTS IN HISTORY  7
      Step          Time      Temperature  Axial Strain
    .0000E+00    .0000E+00   6.5000E+02    .0000E+00
   1.2000E+02   1.2000E+01   6.5000E+02   1.0000E-03
   2.4000E+02   2.4000E+01   6.5000E+02    .0000E+00
   8.4000E+02   8.4000E+01   6.5000E+02   5.0000E-03
   1.1100E+03   1.1100E+02   6.5000E+02   2.7080E-03
   2.2900E+03   2.2900E+02   6.5000E+02   1.2484E-02
   2.5700E+03   2.5700E+02   6.5000E+02   1.0224E-02
  ********* GEOMETRY INFORMATION  ***********
  Number of Cells  1
       For Cell Number : 1
            Material Number :  5
            Volume Fraction :  1.0
            Nodes in cell   :  2
  ********** OUTPUT INFORMATION  ************
  Output at Interface for Material:  1
  ********** MATERIAL INFORMATION  ************
  Material for Cell Number :  1
 Directional B-P Theory with [90] Ply Damage Model of Neu
 Constitutive model: Bodner-Partom with Directional Hardening
  ---------- MATERIAL PROPERTIES  ----------
     T(C)      E(GPa)      NU      CTE(1E-6/C)
  2.3000E+01   1.3300E+02   1.9000E-01   8.8874E+00
  2.6000E+02   1.2800E+02   1.9000E-01   9.8790E+00
  4.8200E+02   1.1900E+02   1.9000E-01   1.0715E+01
  5.3800E+02   1.1500E+02   1.8000E-01   1.0902E+01
  5.9300E+02   1.1200E+02   1.8000E-01   1.1185E+01
  6.5000E+02   1.0500E+02   1.7000E-01   1.1338E+01
  8.1500E+02   5.0000E+01   1.7000E-01   1.1781E+01
  9.0000E+02   2.0000E+01   1.7000E-01   1.2014E+01
  Reference Temperature =  650.0
  ----------------------------------------
      T(C)        N      Z0=Z2(1/S)    Z3(MPa)     M2(1/MPa)
  2.3000E+01   4.8000E+00   1.5500E+03   1.0000E+02   3.5000E-01
  2.6000E+02   3.5000E+00   1.3000E+03   3.0000E+02   3.5000E-01
  3.1500E+02   3.0540E+00   1.2504E+03   3.9000E+02   1.5020E+00
  3.6500E+02   2.6490E+00   1.2054E+03   5.0000E+02   2.5490E+00
  4.1500E+02   2.2430E+00   1.1604E+03   6.6000E+02   3.5970E+00
  4.6500E+02   1.8380E+00   1.1153E+03   9.6000E+02   4.6440E+00
  4.8200E+02   1.7000E+00   1.1000E+03   1.1000E+03   5.0000E+00
  5.0000E+02   1.5000E+00   1.0893E+03   1.3000E+03   5.7630E+00
  5.2500E+02   1.2800E+00   1.0744E+03   1.6700E+03   6.8220E+00
  5.5000E+02   1.1000E+00   1.0595E+03   2.1000E+03   7.8810E+00
  5.7500E+02   9.7000E-01   1.0446E+03   2.6000E+03   8.9410E+00
  6.0000E+02   8.2000E-01   1.0298E+03   3.7000E+03   1.0000E+01
  6.5000E+02   7.4000E-01   1.0000E+03   3.8000E+03   1.0000E+01
  7.6000E+02   5.8000E-01   6.0000E+02   4.0000E+03   1.5000E+01
  8.1500E+02   5.5000E-01   3.0000E+02   4.1000E+03   3.0000E+01
  9.0000E+02   5.5000E-01   3.0000E+02   4.3000E+03   3.0000E+01
  ----------------------------------------
     A1=A2       M1         Z1       R1=R2        DO
 -9999.0 .0 1600.0 3.0 10000.0
```

```
 ----------------------------------------

    Temp         Sm
  2.3000E+01   1.9000E+02
  2.6000E+02   1.3000E+02
  4.8200E+02   7.0000E+01
  5.3800E+02   5.0000E+01
  5.9300E+02   3.6000E+01
  6.5000E+02   1.7000E+01
  8.1500E+02    .0000E+00
 ----------------------------------------

    scho      scl       m     theta      Dstar     beta    Dch
80.0 .0 1.0 100.0 .61 5.000000000000000E-02 .5
 ----------------------------------------

 -------------------- OUTPUT -------------------

  STEP      TIME        TEMPERATURE     SZ-APP        SZ-LAM1       SZ-LAM2       SZ-LAM3         ETOT
    1    1.0000E-01     6.5000E+02    8.7500E-01     8.7500E-01     .0000E+00     .0000E+00     8.3333E-06
   10    1.0000E+00     6.5000E+02    8.7500E+00     8.7500E+00     .0000E+00     .0000E+00     8.3333E-05
   20    2.0000E+00     6.5000E+02    1.7500E+01     1.7500E+01     .0000E+00     .0000E+00     1.6667E-04
   30    3.0000E+00     6.5000E+02    2.6250E+01     2.6250E+01     .0000E+00     .0000E+00     2.5000E-04
   40    4.0000E+00     6.5000E+02    3.5000E+01     3.5000E+01     .0000E+00     .0000E+00     3.3333E-04
   50    5.0000E+00     6.5000E+02    4.3750E+01     4.3750E+01     .0000E+00     .0000E+00     4.1667E-04
   60    6.0000E+00     6.5000E+02    5.2500E+01     5.2500E+01     .0000E+00     .0000E+00     5.0000E-04
   70    7.0000E+00     6.5000E+02    6.1250E+01     6.1250E+01     .0000E+00     .0000E+00     5.8333E-04
   80    8.0000E+00     6.5000E+02    6.9999E+01     6.9999E+01     .0000E+00     .0000E+00     6.6667E-04
   90    9.0000E+00     6.5000E+02    7.8637E+01     7.8637E+01     .0000E+00     .0000E+00     7.5000E-04
  100    1.0000E+01     6.5000E+02    8.6030E+01     8.6030E+01     .0000E+00     .0000E+00     8.3333E-04
  110    1.1000E+01     6.5000E+02    9.2416E+01     9.2416E+01     .0000E+00     .0000E+00     9.1667E-04
  120    1.2000E+01     6.5000E+02    9.7957E+01     9.7957E+01     .0000E+00     .0000E+00     1.0000E-03
  130    1.3000E+01     6.5000E+02    8.8163E+01     8.8163E+01     .0000E+00     .0000E+00     9.1667E-04
  140    1.4000E+01     6.5000E+02    7.9522E+01     7.9522E+01     .0000E+00     .0000E+00     8.3333E-04
  150    1.5000E+01     6.5000E+02    7.0898E+01     7.0898E+01     .0000E+00     .0000E+00     7.5000E-04
  160    1.6000E+01     6.5000E+02    6.2275E+01     6.2275E+01     .0000E+00     .0000E+00     6.6667E-04
  170    1.7000E+01     6.5000E+02    5.3654E+01     5.3654E+01     .0000E+00     .0000E+00     5.8333E-04
  180    1.8000E+01     6.5000E+02    4.5035E+01     4.5035E+01     .0000E+00     .0000E+00     5.0000E-04
  190    1.9000E+01     6.5000E+02    3.6414E+01     3.6414E+01     .0000E+00     .0000E+00     4.1667E-04
  200    2.0000E+01     6.5000E+02    2.7789E+01     2.7789E+01     .0000E+00     .0000E+00     3.3333E-04
  210    2.1000E+01     6.5000E+02    1.9155E+01     1.9155E+01     .0000E+00     .0000E+00     2.5000E-04
  220    2.2000E+01     6.5000E+02    1.0505E+01    1.0505E+01     .0000E+00     .0000E+00     1.6667E-04
  230    2.3000E+01     6.5000E+02    1.8336E+00     1.8336E+00     .0000E+00     .0000E+00     8.3333E-05
  240    2.4000E+01     6.5000E+02   -6.8631E+00    -6.8631E+00     .0000E+00     .0000E+00      .0000E+00
  250    2.5000E+01     6.5000E+02    1.8342E+00     1.8342E+00     .0000E+00     .0000E+00     8.3333E-05
  260    2.6000E+01     6.5000E+02    1.0508E+01     1.0508E+01     .0000E+00     .0000E+00     1.6667E-04
  270    2.7000E+01     6.5000E+02    1.9159E+01     1.9159E+01     .0000E+00     .0000E+00     2.5000E-04
  280    2.8000E+01     6.5000E+02    2.7794E+01     2.7794E+01     .0000E+00     .0000E+00     3.3333E-04
  290    2.9000E+01     6.5000E+02    3.6419E+01     3.6419E+01     .0000E+00     .0000E+00     4.1667E-04
  300    3.0000E+01     6.5000E+02    4.5039E+01     4.5039E+01     .0000E+00     .0000E+00     5.0000E-04
  310    3.1000E+01     6.5000E+02    5.3658E+01     5.3658E+01     .0000E+00     .0000E+00     5.8333E-04
  320    3.2000E+01     6.5000E+02    6.2278E+01     6.2278E+01     .0000E+00     .0000E+00     6.6667E-04
  330    3.3000E+01     6.5000E+02    7.0900E+01     7.0900E+01     .0000E+00     .0000E+00     7.5000E-04
  340    3.4000E+01     6.5000E+02    7.9523E+01     7.9523E+01     .0000E+00     .0000E+00     8.3333E-04
  350    3.5000E+01     6.5000E+02    8.8131E+01     8.8131E+01     .0000E+00     .0000E+00     9.1667E-04
  360    3.6000E+01     6.5000E+02    9.6383E+01     9.6383E+01     .0000E+00     .0000E+00     1.0000E-03
  370    3.7000E+01     6.5000E+02    9.8621E+01     9.8621E+01     .0000E+00     .0000E+00     1.0833E-03
  380    3.8000E+01     6.5000E+02    9.9799E+01     9.9799E+01     .0000E+00     .0000E+00     1.1667E-03
  390    3.9000E+01     6.5000E+02    1.0136E+02     1.0136E+02     .0000E+00     .0000E+00     1.2500E-03
  400    4.0000E+01     6.5000E+02    1.0314E+02     1.0314E+02     .0000E+00     .0000E+00     1.3333E-03
  410    4.1000E+01     6.5000E+02    1.0507E+02     1.0507E+02     .0000E+00     .0000E+00     1.4167E-03
  420    4.2000E+01     6.5000E+02    1.0707E+02     1.0707E+02     .0000E+00     .0000E+00     1.5000E-03
  430    4.3000E+01     6.5000E+02    1.0911E+02     1.0911E+02     .0000E+00     .0000E+00     1.5833E-03
  440    4.4000E+01     6.5000E+02    1.1116E+02     1.1116E+02     .0000E+00     .0000E+00     1.6667E-03
  450    4.5000E+01     6.5000E+02    1.1319E+02     1.1319E+02     .0000E+00     .0000E+00     1.7500E-03
  460    4.6000E+01     6.5000E+02    1.1517E+02     1.1517E+02     .0000E+00     .0000E+00     1.8333E-03
  470    4.7000E+01     6.5000E+02    1.1710E+02     1.1710E+02     .0000E+00     .0000E+00     1.9167E-03
  480    4.8000E+01     6.5000E+02    1.1896E+02     1.1896E+02     .0000E+00     .0000E+00     2.0000E-03
  490    4.9000E+01     6.5000E+02    1.207/4E+02    1.2074E+02      0000E+00     .0000E+00     2.0833E-03
  500    5.0000E+01     6.5000E+02    1.2244E+02     1.2244E+02     .0000E+00     .0000E+00     2.1667E-03
  510    5.1000E+01     6.5000E+02    1.2403E+02     1.2403E+02     .0000E+00     .0000E+00     2.2500E-03
  520    5.2000E+01     6.5000E+02    1.2554E+02     1.2554E+02     .0000E+00     .0000E+00     2.3333E-0
  530    5.3000E+01     6.5000E+02    1.2694E+02     1.2694E+02     .0000E+00     .0000E+00     2.4167E-03
  540    5.4000E+01     6.5000E+02    1.2824E+02     1.2824E+02     .0000E+00     .0000E+00     2.5000E-03
  550    5.5000E+01     6.5000E+02    1.2944E+02     1.2944E+02     .0000E+00     .0000E+00     2.5833E-03
  560    5.6000E+01     6.5000E+02    1.3055E+02     1.3055E+02     .0000E+00     .0000E+00     2.6667E-03
  570    5.7000E+01     6.5000E+02    1.3156E+02     1.3156E+02     .0000E+00     .0000E+00     2.7500E-03
  580    5.8000E+01     6.5000E+02    1.3249E+02     1.3249E+02     .0000E+00     .0000E+00     2.8333E-03
  590    5.9000E+01     6.5000E+02    1.3333E+02     1.3333E+02     .0000E+00     .0000E+00     2.9167E-03
  600    6.0000E+01     6.5000E+02    1.3409E+02     1.3409E+02     .0000E+00     .0000E+00     3.0000E-03
  610    6.1000E+01     6.5000E+02    1.3477E+02     1.3477E+02     .0000E+00     .0000E+00     3.0833E-03
  620    6.2000E+01     6.5000E+02    1.3539E+02     1.3539E+02     .0000E+00     .0000E+00     3.1667E-03
  630    6.3000E+01     6.5000E+02    1.3594E+02     1.3594E+02     .0000E+00     .0000E+00     3.2500E-03
  640    6.4000E+01     6.5000E+02    1.3644E+02     1.3644E+02     .0000E+00     .0000E+00     3.3333E-03
  650    6.5000E+01     6.5000E+02    1.3688E+02     1.3688E+02     .0000E+00     .0000E+00     3.4167E-03
  660    6.6000E+01     6.5000E+02    1.3728E+02     1.3728E+02     .0000E+00     .0000E+00     3.5000E-03
```

670	6.7000E+01	6.5000E+02	1.3763E+02	1.3763E+02	.0000E+00	.0000E+00	3.5833E-03
680	6.8000E+01	6.5000E+02	1.3794E+02	1.3794E+02	.0000E+00	.0000E+00	3.6667E-03
690	6.9000E+01	6.5000E+02	1.3822E+02	1.3822E+02	.0000E+00	.0000E+00	3.7500E-03
700	7.0000E+01	6.5000E+02	1.3846E+02	1.3846E+02	.0000E+00	.0000E+00	3.8333E-03
710	7.1000E+01	6.5000E+02	1.3868E+02	1.3868E+02	.0000E+00	.0000E+00	3.9167E-03
720	7.2000E+01	6.5000E+02	1.3887E+02	1.3887E+02	.0000E+00	.0000E+00	4.0000E-03
730	7.3000E+01	6.5000E+02	1.3904E+02	1.3904E+02	.0000E+00	.0000E+00	4.0833E-03
740	7.4000E+01	6.5000E+02	1.3919E+02	1.3919E+02	.0000E+00	.0000E+00	4.1667E-03
750	**7.5000E+01**	**6.5000E+02**	**1.3932E+02**	**1.3932E+02**	**.0000E+00**	**.0000E+00**	**4.2500E-03**
760	7.6000E+01	6.5000E+02	1.3943E+02	1.3943E+02	.0000E+00	.0000E+00	4.3333E-03
770	7.7000E+01	6.5000E+02	1.3953E+02	1.3953E+02	.0000E+00	.0000E+00	4.4167E-03
780	7.8000E+01	6.5000E+02	1.3962E+02	1.3962E+02	.0000E+00	.0000E+00	4.5000E-03
790	7.9000E+01	6.5000E+02	1.3970E+02	1.3970E+02	.0000E+00	.0000E+00	4.5833E-03
800	8.0000E+01	6.5000E+02	1.3977E+02	1.3977E+02	.0000E+00	.0000E+00	4.6667E-03
810	8.1000E+01	6.5000E+02	1.3983E+02	1.3983E+02	.0000E+00	.0000E+00	4.7500E-03
820	8.2000E+01	6.5000E+02	1.3988E+02	1.3988E+02	.0000E+00	.0000E+00	4.8333E-03
830	8.3000E+01	6.5000E+02	1.3993E+02	1.3993E+02	.0000E+00	.0000E+00	4.9167E-03
840	8.4000E+01	6.5000E+02	1.3997E+02	1.3997E+02	.0000E+00	.0000E+00	5.0000E-03
850	8.5000E+01	6.5000E+02	1.3121E+02	1.3121E+02	.0000E+00	.0000E+00	4.9151E-03
860	8.6000E+01	6.5000E+02	1.2363E+02	1.2363E+02	.0000E+00	.0000E+00	4.8302E-03
870	8.7000E+01	6.5000E+02	1.1673E+02	1.1673E+02	.0000E+00	.0000E+00	4.7453E-03
880	8.8000E+01	6.5000E+02	1.1034E+02	1.1034E+02	.0000E+00	.0000E+00	4.6604E-03
890	8.9000E+01	6.5000E+02	1.0434E+02	1.0434E+02	.0000E+00	.0000E+00	4.5756E-03
900	9.0000E+01	6.5000E+02	9.8644E+01	9.8644E+01	.0000E+00	.0000E+00	4.4907E-03
910	9.1000E+01	6.5000E+02	9.3169E+01	9.3169E+01	.0000E+00	.0000E+00	4.4058E-03
920	9.2000E+01	6.5000E+02	8.7843E+01	8.7843E+01	.0000E+00	.0000E+00	4.3209E-03
930	9.3000E+01	6.5000E+02	8.2610E+01	8.2610E+01	.0000E+00	.0000E+00	4.2360E-03
940	9.4000E+01	6.5000E+02	7.7433E+01	7.7433E+01	.0000E+00	.0000E+00	4.1511E-03
950	9.5000E+01	6.5000E+02	7.2291E+01	7.2291E+01	.0000E+00	.0000E+00	4.0662E-03
960	9.6000E+01	6.5000E+02	6.7179E+01	6.7179E+01	.0000E+00	.0000E+00	3.9813E-03
970	9.7000E+01	6.5000E+02	6.2091E+01	6.2091E+01	.0000E+00	.0000E+00	3.8964E-03
980	9.8000E+01	6.5000E+02	5.7024E+01	5.7024E+01	.0000E+00	.0000E+00	3.8116E-03
990	9.9000E+01	6.5000E+02	5.1971E+01	5.1971E+01	.0000E+00	.0000E+00	3.7267E-03
1000	1.0000E+02	6.5000E+02	4.6919E+01	4.6919E+01	.0000E+00	.0000E+00	3.6418E-03
1010	1.0100E+02	6.5000E+02	4.1849E+01	4.1849E+01	.0000E+00	.0000E+00	3.5569E-03
1020	1.0200E+02	6.5000E+02	3.6737E+01	3.6737E+01	.0000E+00	.0000E+00	3.4720E-03
1030	1.0300E+02	6.5000E+02	3.1547E+01	3.1547E+01	.0000E+00	.0000E+00	3.3871E-03
1040	1.0400E+02	6.5000E+02	2.6230E+01	2.6230E+01	.0000E+00	.0000E+00	3.3022E-03
1050	1.0500E+02	6.5000E+02	2.0726E+01	2.0726E+01	.0000E+00	.0000E+00	3.2173E-03
1060	1.0600E+02	6.5000E+02	1.4954E+01	1.4954E+01	.0000E+00	.0000E+00	3.1324E-03
1070	1.0700E+02	6.5000E+02	8.8139E+00	8.8139E+00	.0000E+00	.0000E+00	3.0476E-03
1080	1.0800E+02	6.5000E+02	2.1921E+00	2.1921E+00	.0000E+00	.0000E+00	2.9627E-03
1090	1.0900E+02	6.5000E+02	-5.0243E+00	-5.0243E+00	.0000E+00	.0000E+00	2.8778E-03
1100	1.1000E+02	6.5000E+02	-1.2904E+01	-1.2904E+01	.0000E+00	.0000E+00	2.7929E-03
1110	1.1100E+02	6.5000E+02	-2.1415E+01	-2.1415E+01	.0000E+00	.0000E+00	2.7080E-03
1120	1.1200E+02	6.5000E+02	-1.3222E+01	-1.3222E+01	.0000E+00	.0000E+00	2.7908E-03
1130	1.1300E+02	6.5000E+02	-5.4379E+00	-5.4379E+00	.0000E+00	.0000E+00	2.8737E-03
1140	1.1400E+02	6.5000E+02	1.7072E+00	1.7072E+00	.0000E+00	.0000E+00	2.9565E-03
1150	1.1500E+02	6.5000E+02	8.2628E+00	8.2628E+00	.0000E+00	.0000E+00	3.0394E-03
1160	1.1600E+02	6.5000E+02	1.4331E+01	1.4331E+01	.0000E+00	.0000E+00	3.1222E-03
1170	1.1700E+02	6.5000E+02	2.0024E+01	2.0024E+01	.0000E+00	.0000E+00	3.2051E-03
1180	1.1800E+02	6.5000E+02	2.5440E+01	2.5440E+01	.0000E+00	.0000E+00	3.2879E-03
1190	1.1900E+02	6.5000E+02	3.0658E+01	3.0658E+01	.0000E+00	.0000E+00	3.3708E-03
1200	1.2000E+02	6.5000E+02	3.5742E+01	3.5742E+01	.0000E+00	.0000E+00	3.4536E-03
1210	1.2100E+02	6.5000E+02	4.0740E+01	4.0740E+01	.0000E+00	.0000E+00	3.5365E-03
1220	1.2200E+02	6.5000E+02	4.5688E+01	4.5688E+01	.0000E+00	.0000E+00	3.6193E-03
1230	1.2300E+02	6.5000E+02	5.0613E+01	5.0613E+01	.0000E+00	.0000E+00	3.7022E-03
1240	1.2400E+02	6.5000E+02	5.5533E+01	5.5533E+01	.0000E+00	.0000E+00	3.7850E-03
1250	1.2500E+02	6.5000E+02	6.0462E+01	6.0462E+01	.0000E+00	.0000E+00	3.8679E-03
1260	1.2600E+02	6.5000E+02	6.5371E+01	6.5371E+01	.0000E+00	.0000E+00	3.9507E-03
1270	1.2700E+02	6.5000E+02	6.9938E+01	6.9938E+01	.0000E+00	.0000E+00	4.0336E-03
1280	1.2800E+02	6.5000E+02	7.3855E+01	7.3855E+01	.0000E+00	.0000E+00	4.1164E-03
1290	1.2900E+02	6.5000E+02	7.7588E+01	7.7588E+01	.0000E+00	.0000E+00	4.1993E-03
1300	1.3000E+02	6.5000E+02	8.1293E+01	8.1293E+01	.0000E+00	.0000E+00	4.2821E-03
1310	1.3100E+02	6.5000E+02	8.4964E+01	8.4964E+01	.0000E+00	.0000E+00	4.3649E-03
1320	1.3200E+02	6.5000E+02	8.8586E+01	8.8586E+01	.0000E+00	.0000E+00	4.4478E-03
1330	1.3300E+02	6.5000E+02	9.2138E+01	9.2138E+01	.0000E+00	.0000E+00	4.5306E-03
1340	1.3400E+02	6.5000E+02	9.5603E+01	9.5603E+01	.0000E+00	.0000E+00	4.6135E-03
1350	1.3500E+02	6.5000E+02	9.8963E+01	9.8963E+01	.0000E+00	.0000E+00	4.6963E-03
1360	1.3600E+02	6.5000E+02	1.0220E+02	1.0220E+02	.0000E+00	.0000E+00	4.7792E-03
1370	1.3700E+02	6.5000E+02	1.0531E+02	1.0531E+02	.0000E+00	.0000E+00	4.8620E-03
1380	1.3800E+02	6.5000E+02	1.0826E+02	1.0826E+02	.0000E+00	.0000E+00	4.9449E-03
1390	1.3900E+02	6.5000E+02	1.1107E+02	1.1107E+02	.0000E+00	.0000E+00	5.0277E-03
1400	1.4000E+02	6.5000E+02	1.1371E+02	1.1371E+02	.0000E+00	.0000E+00	5.1106E-03
1410	1.4100E+02	6.5000E+02	1.1618E+02	1.1618E+02	.0000E+00	.0000E+00	5.1934E-03
1420	1.4200E+02	6.5000E+02	1.1849E+02	1.1849E+02	.0000E+00	.0000E+00	5.2763E-03
1430	1.4300E+02	6.5000E+02	1.2063E+02	1.2063E+02	.0000E+00	.0000E+00	5.3591E-03
1440	1.4400E+02	6.5000E+02	1.2261E+02	1.2261E+02	.0000E+00	.0000E+00	5.4420E-03
1450	1.4500E+02	6.5000E+02	1.2442E+02	1.2442E+02	.0000E+00	.0000E+00	5.5248E-03
1460	1.4600E+02	6.5000E+02	1.2608E+02	1.2608E+02	.0000E+00	.0000E+00	5.6077E-03
1470	1.4700E+02	6.5000E+02	1.2760E+02	1.2760E+02	.0000E+00	.0000E+00	5.6905E-03
1480	1.4800E+02	6.5000E+02	1.2897E+02	1.2897E+02	.0000E+00	.0000E+00	5.7734E-03
1490	1.4900E+02	6.5000E+02	1.3021E+02	1.3021E+02	.0000E+00	.0000E+00	5.8562E-03
1500	1.5000E+02	6.5000E+02	1.3134E+02	1.3134E+02	.0000E+00	.0000E+00	5.9391E-03
1510	1.5100E+02	6.5000E+02	1.3234E+02	1.3234E+02	.0000E+00	.0000E+00	6.0219E-03

1520	1.5200E+02	6.5000E+02	1.3325E+02	1.3325E+02	.0000E+00	.0000E+00	6.1047E-03
1530	1.5300E+02	6.5000E+02	1.3406E+02	1.3406E+02	.0000E+00	.0000E+00	6.1876E-03
1540	1.5400E+02	6.5000E+02	1.3478E+02	1.3478E+02	.0000E+00	.0000E+00	6.2704E-03
1550	1.5500E+02	6.5000E+02	1.3542E+02	1.3542E+02	.0000E+00	.0000E+00	6.3533E-03
1560	1.5600E+02	6.5000E+02	1.3599E+02	1.3599E+02	.0000E+00	.0000E+00	6.4361E-03
1570	1.5700E+02	6.5000E+02	1.3650E+02	1.3650E+02	.0000E+00	.0000E+00	6.5190E-03
1580	1.5800E+02	6.5000E+02	1.3695E+02	1.3695E+02	.0000E+00	.0000E+00	6.6018E-03
1590	1.5900E+02	6.5000E+02	1.3735E+02	1.3735E+02	.0000E+00	.0000E+00	6.6847E-03
1600	1.6000E+02	6.5000E+02	1.3770E+02	1.3770E+02	.0000E+00	.0000E+00	6.7675E-03
1610	1.6100E+02	6.5000E+02	1.3801E+02	1.3801E+02	.0000E+00	.0000E+00	6.8504E-03
1620	1.6200E+02	6.5000E+02	1.3829E+02	1.3829E+02	.0000E+00	.0000E+00	6.9332E-03
1630	1.6300E+02	6.5000E+02	1.3853E+02	1.3853E+02	.0000E+00	.0000E+00	7.0161E-03
1640	1.6400E+02	6.5000E+02	1.3874E+02	1.3874E+02	.0000E+00	.0000E+00	7.0989E-03
1650	1.6500E+02	6.5000E+02	1.3893E+02	1.3893E+02	.0000E+00	.0000E+00	7.1818E-03
1660	1.6600E+02	6.5000E+02	1.3909E+02	1.3909E+02	.0000E+00	.0000E+00	7.2646E-03
1670	1.6700E+02	6.5000E+02	1.3924E+02	1.3924E+02	.0000E+00	.0000E+00	7.3475E-03
1680	1.6800E+02	6.5000E+02	1.3937E+02	1.3937E+02	.0000E+00	.0000E+00	7.4303E-03
1690	1.6900E+02	6.5000E+02	1.3948E+02	1.3948E+02	.0000E+00	.0000E+00	7.5132E-03
1700	1.7000E+02	6.5000E+02	1.3958E+02	1.3958E+02	.0000E+00	.0000E+00	7.5960E-03
1710	1.7100E+02	6.5000E+02	1.3967E+02	1.3967E+02	.0000E+00	.0000E+00	7.6788E-03
1720	1.7200E+02	6.5000E+02	1.3974E+02	1.3974E+02	.0000E+00	.0000E+00	7.7617E-03
1730	1.7300E+02	6.5000E+02	1.3981E+02	1.3981E+02	.0000E+00	.0000E+00	7.8445E-03
1740	1.7400E+02	6.5000E+02	1.3987E+02	1.3987E+02	.0000E+00	.0000E+00	7.9274E-03
1750	1.7500E+02	6.5000E+02	1.3992E+02	1.3992E+02	.0000E+00	.0000E+00	8.0102E-03
1760	1.7600E+02	6.5000E+02	1.3996E+02	1.3996E+02	.0000E+00	.0000E+00	8.0931E-03
1770	1.7700E+02	6.5000E+02	1.3999E+02	1.3999E+02	.0000E+00	.0000E+00	8.1759E-03
1780	1.7800E+02	6.5000E+02	1.4001E+02	1.4001E+02	.0000E+00	.0000E+00	8.2588E-03
1790	1.7900E+02	6.5000E+02	1.4003E+02	1.4003E+02	.0000E+00	.0000E+00	8.3416E-03
1800	1.8000E+02	6.5000E+02	1.4004E+02	1.4004E+02	.0000E+00	.0000E+00	8.4245E-03
1810	1.8100E+02	6.5000E+02	1.4006E+02	1.4006E+02	.0000E+00	.0000E+00	8.5073E-03
1820	1.8200E+02	6.5000E+02	1.4007E+02	1.4007E+02	.0000E+00	.0000E+00	8.5902E-03
1830	1.8300E+02	6.5000E+02	1.4008E+02	1.4008E+02	.0000E+00	.0000E+00	8.6730E-03
1840	1.8400E+02	6.5000E+02	1.4009E+02	1.4009E+02	.0000E+00	.0000E+00	8.7559E-03
1850	1.8500E+02	6.5000E+02	1.4010E+02	1.4010E+02	.0000E+00	.0000E+00	8.8387E-03
1860	1.8600E+02	6.5000E+02	1.4010E+02	1.4010E+02	.0000E+00	.0000E+00	8.9216E-03
1870	1.8700E+02	6.5000E+02	1.4011E+02	1.4011E+02	.0000E+00	.0000E+00	9.0044E-03
1880	1.8800E+02	6.5000E+02	1.4011E+02	1.4011E+02	.0000E+00	.0000E+00	9.0873E-03
1890	1.8900E+02	6.5000E+02	1.4012E+02	1.4012E+02	.0000E+00	.0000E+00	9.1701E-03
1900	1.9000E+02	6.5000E+02	1.4012E+02	1.4012E+02	.0000E+00	.0000E+00	9.2529E-03
1910	1.9100E+02	6.5000E+02	1.4013E+02	1.4013E+02	.0000E+00	.0000E+00	9.3358E-03
1920	1.9200E+02	6.5000E+02	1.4013E+02	1.4013E+02	.0000E+00	.0000E+00	9.4186E-03
1930	1.9300E+02	6.5000E+02	1.4013E+02	1.4013E+02	.0000E+00	.0000E+00	9.5015E-03
1940	1.9400E+02	6.5000E+02	1.4013E+02	1.4013E+02	.0000E+00	.0000E+00	9.5843E-03
1950	1.9500E+02	6.5000E+02	1.4014E+02	1.4014E+02	.0000E+00	.0000E+00	9.6672E-03
1960	1.9600E+02	6.5000E+02	1.4014E+02	1.4014E+02	.0000E+00	.0000E+00	9.7500E-03
1970	1.9700E+02	6.5000E+02	1.4014E+02	1.4014E+02	.0000E+00	.0000E+00	9.8329E-03
1980	1.9800E+02	6.5000E+02	1.4014E+02	1.4014E+02	.0000E+00	.0000E+00	9.9157E-03
1990	1.9900E+02	6.5000E+02	1.4014E+02	1.4014E+02	.0000E+00	.0000E+00	9.9986E-03
2000	2.0000E+02	6.5000E+02	1.4014E+02	1.4014E+02	.0000E+00	.0000E+00	1.0081E-02
2010	2.0100E+02	6.5000E+02	1.4014E+02	1.4014E+02	.0000E+00	.0000E+00	1.0164E-02
2020	2.0200E+02	6.5000E+02	1.4015E+02	1.4015E+02	.0000E+00	.0000E+00	1.0247E-02
2030	2.0300E+02	6.5000E+02	1.4015E+02	1.4015E+02	.0000E+00	.0000E+00	1.0330E-02
2040	2.0400E+02	6.5000E+02	1.4015E+02	1.4015E+02	.0000E+00	.0000E+00	1.0413E-02
2050	2.0500E+02	6.5000E+02	1.4015E+02	1.4015E+02	.0000E+00	.0000E+00	1.0496E-02
2060	2.0600E+02	6.5000E+02	1.4015E+02	1.4015E+02	.0000E+00	.0000E+00	1.0579E-02
2070	2.0700E+02	6.5000E+02	1.4015E+02	1.4015E+02	.0000E+00	.0000E+00	1.0661E-02
2080	2.0800E+02	6.5000E+02	1.4015E+02	1.4015E+02	.0000E+00	.0000E+00	1.0744E-02
2090	2.0900E+02	6.5000E+02	1.4015E+02	1.4015E+02	.0000E+00	.0000E+00	1.0827E-02
2100	2.1000E+02	6.5000E+02	1.4015E+02	1.4015E+02	.0000E+00	.0000E+00	1.0910E-02
2110	2.1100E+02	6.5000E+02	1.4015E+02	1.4015E+02	.0000E+00	.0000E+00	1.0993E-02
2120	2.1200E+02	6.5000E+02	1.4015E+02	1.4015E+02	.0000E+00	.0000E+00	1.1076E-02
2130	2.1300E+02	6.5000E+02	1.4015E+02	1.4015E+02	.0000E+00	.0000E+00	1.1158E-02
2140	2.1400E+02	6.5000E+02	1.4015E+02	1.4015E+02	.0000E+00	.0000E+00	1.1241E-02
2150	2.1500E+02	6.5000E+02	1.4015E+02	1.4015E+02	.0000E+00	.0000E+00	1.1324E-02
2160	2.1600E+02	6.5000E+02	1.4015E+02	1.4015E+02	.0000E+00	.0000E+00	1.1407E-02
2170	2.1700E+02	6.5000E+02	1.4015E+02	1.4015E+02	.0000E+00	.0000E+00	1.1490E-02
2180	2.1800E+02	6.5000E+02	1.4015E+02	1.4015E+02	.0000E+00	.0000E+00	1.1573E-02
2190	2.1900E+02	6.5000E+02	1.4015E+02	1.4015E+02	.0000E+00	.0000E+00	1.1656E-02
2200	2.2000E+02	6.5000E+02	1.4015E+02	1.4015E+02	.0000E+00	.0000E+00	1.1738E-02
2210	2.2100E+02	6.5000E+02	1.4015E+02	1.4015E+02	.0000E+00	.0000E+00	1.1821E-02
2220	2.2200E+02	6.5000E+02	1.4015E+02	1.4015E+02	.0000E+00	.0000E+00	1.1904E-02
2230	2.2300E+02	6.5000E+02	1.4015E+02	1.4015E+02	.0000E+00	.0000E+00	1.1987E-02
2240	2.2400E+02	6.5000E+02	1.4015E+02	1.4015E+02	.0000E+00	.0000E+00	1.2070E-02
2250	2.2500E+02	6.5000E+02	1.4015E+02	1.4015E+02	.0000E+00	.0000E+00	1.2153E-02
2260	2.2600E+02	6.5000E+02	1.4015E+02	1.4015E+02	.0000E+00	.0000E+00	1.2235E-02
2270	2.2700E+02	6.5000E+02	1.4015E+02	1.4015E+02	.0000E+00	.0000E+00	1.2318E-02
2280	2.2800E+02	6.5000E+02	1.4015E+02	1.4015E+02	.0000E+00	.0000E+00	1.2401E-02
2290	2.2900E+02	6.5000E+02	1.4015E+02	1.4015E+02	.0000E+00	.0000E+00	1.2484E-02
2300	2.3000E+02	6.5000E+02	1.3159E+02	1.3159E+02	.0000E+00	.0000E+00	1.2403E-02
2310	2.3100E+02	6.5000E+02	1.2419E+02	1.2419E+02	.0000E+00	.0000E+00	1.2323E-02
2320	2.3200E+02	6.5000E+02	1.1746E+02	1.1746E+02	.0000E+00	.0000E+00	1.2242E-02
2330	2.3300E+02	6.5000E+02	1.1124E+02	1.1124E+02	.0000E+00	.0000E+00	1.2161E-02
2340	2.3400E+02	6.5000E+02	1.0542E+02	1.0542E+02	.0000E+00	.0000E+00	1.2080E-02
2350	2.3500E+02	6.5000E+02	9.9903E+01	9.9903E+01	.0000E+00	.0000E+00	1.2000E-02
2360	2.3600E+02	6.5000E+02	9.4622E+01	9.4622E+01	.0000E+00	.0000E+00	1.1919E-02
2370	2.3700E+02	6.5000E+02	8.9508E+01	8.9508E+01	.0000E+00	.0000E+00	1.1838E-02

2380	2.3800E+02	6.5000E+02	8.4502E+01	8.4502E+01	.0000E+00	.0000E+00	1.1758E-02
2390	2.3900E+02	6.5000E+02	7.9563E+01	7.9563E+01	.0000E+00	.0000E+00	1.1677E-02
2400	2.4000E+02	6.5000E+02	7.4665E+01	7.4665E+01	.0000E+00	.0000E+00	1.1596E-02
2410	2.4100E+02	6.5000E+02	6.9796E+01	6.9796E+01	.0000E+00	.0000E+00	1.1515E-02
2420	2.4200E+02	6.5000E+02	6.4951E+01	6.4951E+01	.0000E+00	.0000E+00	1.1435E-02
2430	2.4300E+02	6.5000E+02	6.0128E+01	6.0128E+01	.0000E+00	.0000E+00	1.1354E-02
2440	2.4400E+02	6.5000E+02	5.5322E+01	5.5322E+01	.0000E+00	.0000E+00	1.1273E-02
2450	2.4500E+02	6.5000E+02	5.0524E+01	5.0524E+01	.0000E+00	.0000E+00	1.1193E-02
2460	2.4600E+02	6.5000E+02	4.5723E+01	4.5723E+01	.0000E+00	.0000E+00	1.1112E-02
2470	2.4700E+02	6.5000E+02	4.0902E+01	4.0902E+01	.0000E+00	.0000E+00	1.1031E-02
2480	2.4800E+02	6.5000E+02	3.6037E+01	3.6037E+01	.0000E+00	.0000E+00	1.0950E-02
2490	2.4900E+02	6.5000E+02	3.1096E+01	3.1096E+01	.0000E+00	.0000E+00	1.0870E-02
2500	2.5000E+02	6.5000E+02	2.6037E+01	2.6037E+01	.0000E+00	.0000E+00	1.0789E-02
2510	2.5100E+02	6.5000E+02	2.0805E+01	2.0805E+01	.0000E+00	.0000E+00	1.0708E-02
2520	2.5200E+02	6.5000E+02	1.5332E+01	1.5332E+01	.0000E+00	.0000E+00	1.0628E-02
2530	2.5300E+02	6.5000E+02	9.5333E+00	9.5333E+00	.0000E+00	.0000E+00	1.0547E-02
2540	2.5400E+02	6.5000E+02	3.3096E+00	3.3096E+00	.0000E+00	.0000E+00	1.0466E-02
2550	2.5500E+02	6.5000E+02	-3.4375E+00	-3.4375E+00	.0000E+00	.0000E+00	1.0385E-02
2560	2.5600E+02	6.5000E+02	-1.0778E+01	-1.0778E+01	.0000E+00	.0000E+00	1.0305E-02
2570	2.5700E+02	6.5000E+02	-1.8711E+01	-1.8711E+01	.0000E+00	.0000E+00	1.0224E-02

APPENDIX D

Listing of FIDEP2 Source Code

```
PROGRAM FIDEP2_8
C
C                 Copyright 1996 University of Dayton
C                         All Rights Reserved.
C
C           This material may be reproduced by or for the U.S.
C           government pursuant to the copyright license under
C           the clause of DFARS 252.227-7013 (Oct 1988).
C
C ======================================================================
C |                                                                    |
C |                                                                    |
C |                                                                    |
C |                                                                    |
C |                                                                    |
C |   @@@@@@@@@  @@@@@@@  @@@@@      @@@@@@@@  @@@@@@        @@@@     |
C |   @@@@@@@@@  @@@@@@@  @@@@@@@    @@@@@@@@  @@@@@@@@    @@@@@@@@   |
C |   @@@         @@@    @@@  @@@   @@@       @@@   @@@  @@@    @@@   |
C |   @@@@@@      @@@    @@@   @@@  @@@@@@    @@@   @@@         @@@   |
C |   @@@@@@      @@@    @@@   @@@  @@@@@@    @@@@@@@@@         @@@   |
C |   @@@         @@@    @@@   @@@  @@@       @@@@@@        @@@@     |
C |   @@@         @@@    @@@  @@@   @@@       @@@          @@@        |
C |   @@@       @@@@@@@  @@@@@@@    @@@@@@@@  @@@        @@@@@@@@@    |
C |   @@@       @@@@@@@  @@@@@      @@@@@@@@  @@@        @@@@@@@@@    |
C |                                                                    |
C |                                                                    |
C |                                                                    |
C |                                                                    |
C |                                                                    |
C ======================================================================
C
C     LAST DATE OF CHANGE: June 1996
C
C     PROGRAMMERS:              DEMIRKAN COKER
C                               JOSEPH L. KROUPA
C
C     SUPERVISOR:               NOEL E. ASHBAUGH
C
C                    UNIVERSITY OF DAYTON RESEARCH INSTITUTE
```

```
C                   300 COLLEGE PARK
C                   DAYTON, OHIO 45469-0128
C                   (513) 255-1362
C
C ======================================================================
C
C   Material models available:
C
C   A) Thermo-elastic
C   B) Thermo-elastic plastic
C   C) Bodner Partom with back stress
C   D) Bodner Partom with directional hardening
C   E) Bodner Partom with directional hardening
C      and damage [90] model
C   F) Bodner Partom with directional hardening (new formulation)
C
C   Composite geomeries available:
C
C   A) Concentric cylinder
C   B) Laminate from 1 to 10 plys
C   C) Concentric cylinder with parallel [90] ply
C
C C ====================================================================
C
      IMPLICIT DOUBLE PRECISION ( A-H,O-Z )
C
      PARAMETER( LDA = 150, MM = 10, MR = 40, ML = 100, MC = 40 )
      PARAMETER( NN = 50)
C *** loading input paramaters
      COMMON /LOAD1/  BT(ML), BSAPP(ML), BTAU(ML),
     $                BEZ(ML), BSRAPP(ML), NBLOCK(ML),
     $                NCYCLE(ML), NCSTART(ML), NCEND(ML), NCBLOCK
C *** loading parameters
      COMMON /LOAD2/  VF(MM), EZCOOL, IMAT(MM),NODES(MM),
     $                NOMAT, ICASE, ILOAD,ISTRAIN(MM),ISTRAIN2(MM)
C *** output variables
      COMMON /LOADO/  INTOUT(ML),IOUT(ML,20),
     $                IPRINTSTEP(ML),ISTEPOUT(ML)
C *** variables for strain controlled loading of ccm
C *** applied total and incremental loads at step i
      COMMON /LOADT/  T, SZ, EZ, SR, TAU, DT,
     $                TINCR, SZINCR, EZINCR, SRINCR, DTAU,
     $                TIME, ICYCLE, IBLOCK
C *** material input parameters
      COMMON /READM/  NROW(MM,7), NCOL(MM,7), TP(MM,MR,MC),
```

```
     $                AT(MM,MR,7), TREF(MM), NSET(MM)
C *** material input header lines and names
      COMMON /NAME1/  NAME(MM), HEADER(MM,7)
C *** properties at temperature at step i
      COMMON /PROP /  P(MM,MC)
C *** elastic properties and composite properties at step i
      COMMON /ELASX/ TEO(NN),TE(NN),TNU(NN),TCTE(NN),ECOM,CTECOM
C *** plastic properties at step i
      COMMON /MAT2A /  TSY(NN), TEP(NN)
C *** bodner-partom with backstress properties at step i
      COMMON /MAT5A /  TN(NN), TZ0(NN), TF1(NN), TF3(NN),
     $                TBSMAX(NN),  TD0(NN)
      COMMON /MAT5B/  F3OLD(NN), BS(6,NN), SDEVOLD(6,NN)
C *** bodner-partom with directional hardening props at step i
      COMMON /MAT6A / TND(NN), TZ0D(NN), TZ3(NN), TM2(NN),
     $                TA1(NN), TM1(NN), TZ1(NN), TR1(NN),
     $                TR2(NN), TD0D(NN), TZ2(NN),
     $                DTZ1(NN), DTZ2(NN), DTZ3(NN)
      COMMON /MAT7A / TA1A(NN),TA1B(NN),TA1C(NN),
     $                TM1A(NN),TM1B(NN),TM1C(NN),
     $                TA2(NN)
      COMMON /MAT6B/  BETA(6,NN),ZD(NN),ZI(NN),ZTOT(NN)
C *** concentric cylinder model parameters for geometry
      COMMON /CCM1 /  RAD(LDA), IBEG(MM), IEND(MM), NTOT
C *** setting up of the ax=b system and the coefficients
      COMMON /MATRIX/ AMAT(LDA,LDA), BMAT(LDA), NRA,
     $                IPVT(LDA)
      COMMON /MATRIX2/ AA(NN), BB(NN), CC(NN), DD(NN),
     $                FF(NN), GG(NN), HH(NN), QQ(NN), PP(NN)
C *** stresses and strains for use in output and inelasticity routine
      COMMON /STRES/  S(6,NN), SDEV(6,NN),
     $                SEFF(NN), SE(NN), SEFFOLD(NN)
      COMMON /STRAI/  ETOT(6,NN), DEP(6,NN), EME(6,NN), ETH(NN),
     $                DEFF(NN), EPEFF(NN), DEPOLD(6,NN)
C *** stiffness reduction variables for the [90] ply
      COMMON /STIF / IDAMAGE(10), D(NN), ETA(NN), SPEAK,
     $               DSM, DSCH, DSCL, DM, DTHETA, DDSTAR, DBETA, DDCH
C ======================================================================
COMMON /CONTROL/ TOLER1, TOLER2, RELAX, FAST, ICOUNT,
     $                 ISUBTOT, IZMAX, MAXITER
C
      CHARACTER*80    NAME, HEADER
      REAL*8          EP2(6,NN)
      INTEGER         ITYPE(MM)
C
```

```
C     Initialize the material property and loading arrays
      CALL INITIAL( ITYPE, EP2, XT1 )
C     Read loading conditions, geometry and output preferences
      CALL READLOAD
C     Read input data; constitutive model and corresponding properties
      CALL READMAT( ITYPE )
C     Compute new cte if reference temp is not the same as the first
C     Temperature in the loading file
      CALL NEWCTE( BT(1) )
C     Rewind and close input files
      CALL CLOSEFILES
C     Write loading and material data into output file 15
      CALL WRITEMAT( ITYPE )
C     Define physical and geometric parameters
      CALL GEOMETRY
      ICOUNT = 0
      CALL OUTPUT1( ICOUNT, ITYPE, EP2, BS )
      T = BT(1)
      IFLIP  = 1
C     Interpolate for material properties at inital temperature t
      CALL PROPT( ITYPE, T )
C     Initialize all state variables
      CALL PROPNODES( ITYPE, ICOUNT )
C     Cycle blocks
      DO 200 IBLOCK = 1, NCBLOCK
C       Reset counter and time
        ICOUNT = 1
        TIME   = BTAU(NCSTART(IBLOCK))
        WRITE(6,*)
        WRITE(6,*) ' *** BLOCK *** ',IBLOCK
        DO 300 ICYCLE = 1, NCYCLE(IBLOCK)
          TAU   = BTAU(NCSTART(IBLOCK))
          WRITE(6,*) '  *** CYCLE *** ',ICYCLE
C         Block loading            >>>>>>>>>>>>>>>>>>>>>>>>>
          DO 400 IB = NCSTART(IBLOCK), NCEND(IBLOCK)
            NSTEPS = NBLOCK(IB+1) - NBLOCK(IB)
           if(icount .eq. 1 .and. istepout(iblock) .le. 1) then
           CALL OUTPUT1( ICOUNT, ITYPE, EP2, BS )
           endif
C           Incremental loading       >>>>>>>>>>>>>>>>>>>>>>>>>
            FAST =  2.
            DO 500 ISTEP = 1, NSTEPS
            FAST0 = FAST
C   Check and Convert to STRAIN Control
               IF(ISTRAIN(IFLIP)  .EQ. ICOUNT .AND.
```

```
     $             ISTRAIN2(IFLIP) .EQ. IBLOCK)  THEN
                   EZCOOL = ETOT(3,1)
                   WRITE(*,*) 'Converting to Strain Control '
                   IFLIP = IFLIP + 1
                   ILOAD = 1
                 ENDIF
                 IF(-ISTRAIN(IFLIP)  .EQ. ICOUNT .AND.
     $              -ISTRAIN2(IFLIP) .EQ. IBLOCK)  THEN
                   BSAPP(IB)   = SZ
                   BSAPP(IB+1) = BEZ(IB+1)
                   WRITE(*,*) 'Converting to Stress Control '
                   IFLIP = IFLIP + 1
                   ILOAD = 0
                 ENDIF
               CALL SUBCUT(ITYPE, IB, NSTEPS, ISTEP)
C              For concentric cylinder model create a-matrix and the l-u decom
                 DO 600 ISUB = 1, ISUBTOT
                   SUB    = ISUB
                   SUBTOT = ISUBTOT
                   RSTEP  = ISTEP - 1
                   STEP   = RSTEP + SUB/SUBTOT
C                  Compute total and incremental temperature, app stresses
C                  applied strain, and time.
                   CALL LOAD( IB, NSTEPS, STEP, BT(1) )
C                  Interpolate for material properties at temperature t
                   CALL PROPT( ITYPE, T )
C                  Assign material properties to nodes
                   CALL PROPNODES( ITYPE, ICOUNT )
C                  Stiffness reduction at the beginning of each step using old ep
C                  Call damage( ep2, icount )
C                  Compute stresses assuming elastic behavior
                   CALL STRESS( EP2, ICOUNT )
C                  Compute inelastic strain increments and iterate to converge to
C                  Right combination of stresses and strains.
                   CALL INELASTIC(ITYPE, EP2 )
 600           CONTINUE
c
               FAST = FAST0*0.95 + FAST*0.05
               ITEMP = ICOUNT - ISTEPOUT(IBLOCK)
               if(itemp .ge. 0) then
               IF(MOD(ITEMP,IPRINTSTEP(IBLOCK))  .EQ. 0 .OR.
     $            IPRINTSTEP(IBLOCK) .EQ. 1) THEN
                   CALL OUTPUT1( ICOUNT, ITYPE, EP2, BS )
               ENDIF
               endif
```

```
C             Fract = 0.007
C             If(eme(3,1) .gt. fract) then
C               Call output1( icount, itype, ep2, bs )
C               Stop
C             Endif
C             Write something at sometime intervals
              IF(MOD(ICOUNT,100) .EQ. 0)
     $          WRITE(6,*) ' BLOCK ',IBLOCK, '    COUNT ',
     $            ICOUNT,  ' WITH FAST = ' , FAST
              ICOUNT = ICOUNT + 1
 500        CONTINUE
 400      CONTINUE
 300    CONTINUE
 200  CONTINUE
C     Print out runtime of the code.
      CALL PRINTTIME( XT1, ICOUNT, NTOT )
      STOP
      END
C
C =====================================================================
C  Printtime
C   Reports cpu time of the problem (see local fortran manual for
C   Machine dependent time functions)
C =====================================================================
C
      SUBROUTINE PRINTTIME( XT1, ICOUNT, NTOT )
C
      IMPLICIT DOUBLE PRECISION ( A-H,O-Z )
C
      REAL*4  XAT(2), DELTA
C
      XAT(1) = 0.0
      XAT(2) = 0.0
      DELTA  = 0.0
CJoe  delta  =  dtime(xat)
CJoe  write(6,100) xat(1), ntot, icount
      WRITE(6,200)
 100  FORMAT( 1X,'RUNTIME IS ',F12.6,' SECONDS FOR ',I5,' NODES AND ',
     $        I7, ' COMPUTATIONAL STEPS')
 200  FORMAT(//,' ********** ANALYSIS COMPLETED  ********** ',/////)
      RETURN
      END
C
C =====================================================================
C Initial
```

```
C Initialize variables
C ======================================================================
C
      SUBROUTINE INITIAL( ITYPE, EP, XT1 )
C
      IMPLICIT DOUBLE PRECISION ( A-H,O-Z )
C
      PARAMETER( LDA = 150, MM = 10, MR = 40, ML = 100, MC = 40 )
      PARAMETER( NN = 50)
      COMMON  /LOAD1/  BT(ML), BSAPP(ML), BTAU(ML),
     $                 BEZ(ML), BSRAPP(ML), NBLOCK(ML),
     $                NCYCLE(ML), NCSTART(ML), NCEND(ML), NCBLOCK
      COMMON /LOAD2/  VF(MM), EZCOOL, IMAT(MM),NODES(MM),
     $                NOMAT, ICASE, ILOAD,ISTRAIN(MM),ISTRAIN2(MM)
      COMMON /LOADT/  T, SZ, EZ, SR, TAU, DT,
     $                TINCR, SZINCR, EZINCR, SRINCR, DTAU,
     $                TIME, ICYCLE, IBLOCK
      COMMON  /READM/  NROW(MM,7), NCOL(MM,7), TP(MM,MR,MC),
     $                 AT(MM,MR,7), TREF(MM), NSET(MM)
      COMMON  /PROP/   P(MM,MC)
      COMMON /STRES/  S(6,NN),  SDEV(6,NN),
     $                SEFF(NN), SE(NN), SEFFOLD(NN)
      COMMON /STRAI/  ETOT(6,NN), DEP(6,NN), EME(6,NN), ETH(NN),
     $                DEFF(NN), EPEFF(NN), DEPOLD(6,NN)
      COMMON /STIF / IDAMAGE(10), D(NN), ETA(NN), SPEAK,
     $            DSM, DSCH, DSCL, DM, DTHETA, DDSTAR, DBETA, DDCH
      COMMON /MAT2A /  TSY(NN), TEP(NN)
      COMMON /MAT5A /  TN(NN), TZ0(NN), TF1(NN), TF3(NN),
     $                TBSMAX(NN),  TD0(NN)
      COMMON /MAT5B/  F3OLD(NN), BS(6,NN), SDEVOLD(6,NN)
      COMMON /MAT6A / TND(NN), TZ0D(NN), TZ3(NN), TM2(NN),
     $                TA1(NN), TM1(NN), TZ1(NN), TR1(NN),
     $                TR2(NN), TD0D(NN), TZ2(NN),
     $                DTZ1(NN), DTZ2(NN), DTZ3(NN)
      COMMON /MAT6B/  BETA(6,NN),ZD(NN),ZI(NN),ZTOT(NN)
      COMMON /MAT7A / TA1A(NN),TA1B(NN),TA1C(NN),
     $                TM1A(NN),TM1B(NN),TM1C(NN),
     $                TA2(NN)
      COMMON /CONTROL/ TOLER1, TOLER2, RELAX, FAST, ICOUNT,
     $                 ISUBTOT, IZMAX, MAXITER
C
      REAL*8          EP(6,NN)
      INTEGER         ITYPE(MM)
CJoe  real*4          xat(2)
C
```

```
      XT1 =  0.0
CJoe  xt1 =  dtime(xat)
      TIME = 0.0
      ISUBTOT = 1
      FAST   = 1
      SZ  = 0
      EZ  = 0
      SR  = 0
      TAU = 0
      DT  = 0
      TINCR = 0
      SZINCR = 0
      EZINCR = 0
      SRINCR = 0
      DTA = 0
      EZCOOL = 0
      SPEAK  = 0
      DSM  =   0
      DSCH  =   0
      DSCL  =   0
      DM  =   0
      DTHETA  =   0
      DDSTAR  =   0
      DBETA  =   0
      DDC  =   0
      STEP = 0.0
      DO 3 I = 1,ML
        BT(I) = 0.0
        BSAPP(I) = 0.0
        BTAU(I)  = 0.0
        BEZ(I)   = 0.0
        BSRAPP(I) = 0.0
        NBLOCK(I) = 0.0
 3    CONTINUE
      DO 4  I = 1, MM
        VF(I) = 0.0
        TREF(I) = 0.0
        NSET(I) = 0.0
        IMAT(I) = 0.0
        ISTRAIN(I) = 0
        ISTRAIN2(I) = 0
 4    CONTINUE
      DO 5 I=1,6
        DO 5 J=1,NN
          EP(I,J) = 0.0
```

```
          S(I,J) = 0
          SDEV(I,J)      = 0.0
          ETOT(I,J)      = 0.0
          DEP(I,J)       = 0.0
          EME(I,J)       = 0.0
          ETH(J)         = 0.0
          DEFF(J)        = 0.0
          EPEFF(J)       = 0.0
          DEPOLD(I,J)    = 0.0
          SEFF(J)        = 0.0
          SE(J)          = 0.0
          SEFFOLD(J)     = 0.0
          D(J)           = 0.0
          ETA(J)         = 0.0
          TSY(J)         = 0.0
          TEP(J)         = 0.0
          TN(J)          = 0.0
          TZ0(J)         = 0.0
          TF1(J)         = 0.0
          TF3(J)         = 0.0
          TBSMAX(J)      = 0.0
          TD0(J)         = 0.0
          F3OLD(J)       = 0.0
          BS(I,J)        = 0.0
          TND(J)         = 0.0
          TZ0D(J)        = 0.0
          TZ3(J)         = 0.0
          TM2(J)         = 0.0
          TA1(J)         = 0.0
          TM1(J)         = 0.0
          TZ1(J)         = 0.0
          TR1(J)         = 0.0
          TR2(J)         = 0.0
          TD0D(J)        = 0.0
          TZ2(J)         = 0.0
          DTZ1(J)        = 0.0
          DTZ2(J)        = 0.0
          DTZ3(J)        = 0.0
          BETA(I,J)      = 0.0
          ZD(J)          = 0.0
          ZI(J)          = 0.0
          ZTOT(J)        = 0.0
5     CONTINUE
      DO 10 IM = 1, MM
        DO 11 IS = 1,7
```

```
          NROW(IM,IS) = 0
          NCOL(IM,IS) = 0
          DO 11 IR=1,MR
            AT(IM,IR,IS) = 0.0
 11     CONTINUE
        DO 12 IC = 1, MC
          P(IM,IC) = 0.0
          DO 12 IR = 1, MR
          TP(IM,IR,IC) = 0.0
 12     CONTINUE
 10   CONTINUE
      RETURN
      END
C
C =====================================================================
C Readload
C Read loading conditions, geometry and output preferences
C =====================================================================
C
      SUBROUTINE READLOAD
C
      IMPLICIT DOUBLE PRECISION ( A-H,O-Z )
C
      PARAMETER( LDA = 150, MM = 10, MR = 40, ML = 100, MC = 40 )
      PARAMETER( NN=50)
      COMMON /LOADO/  INTOUT(ML),IOUT(ML,20),
     $                IPRINTSTEP(ML),ISTEPOUT(ML)
      COMMON /LOAD1/  BT(ML), BSAPP(ML), BTAU(ML), BEZ(ML),
     $                BSRAPP(ML), NBLOCK(ML),
     $                NCYCLE(ML), NCSTART(ML), NCEND(ML), NCBLOCK
      COMMON /LOAD2/  VF(MM), EZCOOL, IMAT(MM),NODES(MM),
     $                NOMAT, ICASE, ILOAD,ISTRAIN(MM),ISTRAIN2(MM)
      COMMON /STIF / IDAMAGE(10), D(NN), ETA(NN), SPEAK,
     $               DSM, DSCH, DSCL, DM, DTHETA, DDSTAR, DBETA, DDCH
      CHARACTER*80    TITLE, HEADER
      CHARACTER*30    MATDAT, LOADDAT, OUT1, OUT2
C
      ICS_FLAG = 0
C     Open input and output files
      WRITE(6,10)
 100  WRITE(6,*)
      WRITE(6,*)  '   ENTER INPUT LOADING DATA FILE '
      WRITE(6,*)
      READ(5,755) LOADDAT
      WRITE(6,*)
```

```
      OPEN( UNIT = 11, ERR=109, FILE = LOADDAT, STATUS = 'OLD' )
      GOTO 110
 109  WRITE(6,*)
      WRITE(6,*) '    ERROR OPENING FILE - TRY AGAIN  '
      WRITE(6,*)
      WRITE(6,*)
      GOTO 100
 110  WRITE(6,*)  '   ENTER NAME OF YOUR INTERFACE OUTPUT FILE '
      WRITE(6,*)
      READ(5,755) OUT1
      WRITE(6,*)
      OPEN( UNIT = 15, ERR=111, FILE = OUT1,    STATUS = 'NEW' )
      GOTO 107
 111  WRITE(6,*)
      WRITE(6,*) '    ERROR OPENING FILE - TRY AGAIN '
      WRITE(6,*)
      WRITE(6,*)
      GOTO 110
 107  CONTINUE
C     Rewriting of input data
      WRITE(15,10)
 10   FORMAT(/,10X,' ************************************ ',/,
     $         10X,' *                                  * ',/,
     $         10X,' *   F I D E P 2 - VERSION 8        * ',/,
     $         10X,' *                                  * ',/,
     $         10X,' ************************************ ',//)
CJoe  write(15,756) loaddat
      WRITE(15,*)
      WRITE(15,*)
      WRITE(15,*)  ' ************ PROBLEM TITLE ************ '
      WRITE(15,*)
      READ(11,750)  TITLE
      WRITE(15,750) TITLE
      READ(11,*)    ICASE, ILOAD
      WRITE(15,*)
      WRITE(15,*)
      WRITE(15,*)  ' ************ GEOMETRY TYPE ************ '
      WRITE(15,*)
      IF( ICASE .EQ. 1)THEN
        WRITE(15,*) '    CONCENTRIC CYLINDER MODEL '
      ELSEIF( ICASE .EQ. 2)THEN
        WRITE(15,*) '    1-D LAMINATE MODEL '
      ELSEIF( ICASE .EQ. 3)THEN
        WRITE(15,*) '    CONCENTRIC CYLINDER MODEL WITH [90] '
      ENDIF
```

```
      WRITE(15,*)
      WRITE(15,*)
      WRITE(15,*)  ' ************ LOADING TYPE ************ '
      WRITE(15,*)
      IF (ILOAD .EQ. 0) THEN
        WRITE(15,*)  '     STRESS CONTROL '
      ELSE
        WRITE(15,*)  '     STRAIN CONTROL '
      ENDIF
C     Additional prompt commands
      IF(ICASE .NE. 2) THEN
        WRITE(6,*)
 120    WRITE(6,*) '   ENTER NAME OF AVERAGE STRESS OUTPUT FILE '
        WRITE(6,*)
        READ(5,755) OUT2
        WRITE(6,*)
        OPEN( UNIT = 16, ERR=121, FILE = OUT2, STATUS = 'NEW' )
        WRITE(16,10)
        WRITE(16,*)
        WRITE(16,*)
        WRITE(16,*)  ' ************ PROBLEM TITLE ************ '
        WRITE(16,*)
        WRITE(16,750) TITLE
        WRITE(16,*)
        WRITE(16,*)
        WRITE(16,*)
        WRITE(16,*)  ' ---------- AVERAGE STRESS OUTPUT ----------'
        WRITE(16,*)
        GOTO 122
 121    WRITE(6,*)
        WRITE(6,*) '    ERROR OPENING FILE - TRY AGAIN '
        WRITE(6,*)
        WRITE(6,*)
        GOTO 120
 122    CONTINUE
      ENDIF
C     Continue reading loading file
      READ(11,755)    MATDAT
CJoe  write(15,757)   matdat
      OPEN( UNIT = 10,ERR=141, FILE = MATDAT,  STATUS = 'OLD' )
      GOTO 140
 141  WRITE(6,*)
      WRITE(6,*) '  MATERIAL DATA-BASE NOT FOUND '
      WRITE(6,*)
      STOP
```

```
 140  READ(11,*)    NCBLOCK
      WRITE(15,*)
      WRITE(15,*)
      WRITE(15,*)  ' ********* LOADING HISTORY ************'
      WRITE(15,*)
      WRITE(15,*)  '  NUMBER OF CYCLE BLOCKS ' , NCBLOCK
      WRITE(15,*)
      WRITE(15,*)
      INDEX  = 0
      IFLIP = 1
      IFLAG = 0
      DO 150  I2 = 1, NCBLOCK
        READ(11,750)  HEADER
        READ(11,*)  NLOAD, NCYCLE(I2) ,IPRINTSTEP(I2),ISTEPOUT(I2),
     $           INTOUT(I2), NIOUT
C       Open output file for cross-sectional stresses
        IF (NIOUT .GT. 0) THEN
          READ(11,*) (IOUT(I2,J1), J1 = 1, NIOUT)
          IF(ICS_FLAG .EQ. 0) THEN
            WRITE(6,*)
 130        WRITE(6,*)
     $      ' ENTER NAME OF CROSS-SECTIONAL STRESS OUTPUT FILE '
            WRITE(6,*)
            READ(5,755) OUT2
            WRITE(6,*)
            OPEN( UNIT = 17, ERR=131, FILE = OUT2, STATUS = 'NEW' )
            WRITE(17,10)
            WRITE(17,*)
            WRITE(17,*)
            WRITE(17,*)  ' ************ PROBLEM TITLE ************ '
            WRITE(17,*)
            WRITE(17,750) TITLE
            WRITE(17,*)
            WRITE(17,*)
            WRITE(17,*)
            WRITE(17,*)
     $      ' ------- CROSS-SECTIONAL STRESS OUTPUT ---------'
            WRITE(17,*)
            ICS_FLAG = 1
          ENDIF
          GOTO 132
 131      WRITE(6,*)
          WRITE(6,*) '    ERROR OPENING FILE - TRY AGAIN '
          WRITE(6,*)
          WRITE(6,*)
```

```
          GOTO 130
 132      CONTINUE
        ENDIF
        WRITE(15,*)
        WRITE(15,*)  ' ********* BLOCK HISTORY DATA  ************'
        WRITE(15,*)
        WRITE(15,*)  '  FOR CYCLE BLOCK        ', I2
        WRITE(15,*)  '  NUMBER OF LOAD POINTS ', NLOAD
        WRITE(15,*)  '  NUMBER OF CYCLES      ', NCYCLE(I2)
        WRITE(15,*)
        READ(11,750)  HEADER
        WRITE(15,*)
        IF( ILOAD .EQ. 0 ) THEN
          WRITE(15,103)
          DO 165 I3 = 1, NLOAD
            INDEX = INDEX + 1
            I = INDEX
            IF(I3 .EQ. 1)       NCSTART(I2)=I
            IF(I3 .EQ. NLOAD)   NCEND(I2)=I-1
            READ(11,*)  NBLOCK(I), BTAU(I), BT(I), BSAPP(I), BSRAPP(I)
            WRITE(15,754) NBLOCK(I),BTAU(I),BT(I), BSAPP(I), BSRAPP(I)
165       CONTINUE
        ELSE
          WRITE(15,104)
          DO 166 I3 = 1 , NLOAD
            INDEX = INDEX + 1
            I    = INDEX
            IF(I3 .EQ. 1)       NCSTART(I2)=I
            IF(I3 .EQ. NLOAD)   NCEND(I2)=I
            READ(11,*)  NBLOCK(I), BTAU(I), BT(I), BEZ(I)
            WRITE(15,754) NBLOCK(I), BTAU(I), BT(I), BEZ(I)
C           Find first nonzero strain step
            IF(NBLOCK(I) .LT. 0) THEN
              NBLOCK(I)       = - NBLOCK(I)
              ISTRAIN(IFLIP)  = - NBLOCK(I-1)
              ISTRAIN2(IFLIP) = - I2
              IF(ISTRAIN(IFLIP) .EQ. 0) ISTRAIN(IFLIP) = -1
              IFLIP = IFLIP + 1
              IFLAG = 0
            ENDIF
            IF(I .gt. 1) then
              IF( ABS(BEZ(I))   .GT. 1.E-8 .AND.
     $            ABS(BEZ(I-1)) .LT. 1.E-8 .AND.
     $                     IFLAG .EQ.  0 )  THEN
                ISTRAIN(IFLIP)  = NBLOCK(I-1)
```

```
                ISTRAIN2(IFLIP) = I2
                IF(ISTRAIN(IFLIP) .EQ. 0) ISTRAIN(IFLIP) = 1
                IFLIP = IFLIP + 1
                IFLAG = 1
              ENDIF
            ENDIF
166       CONTINUE
        ENDIF
        IF (INDEX .GT. ML) THEN
          WRITE(6,*)
          WRITE(6,*)
          WRITE(6,*) ' ********************************* '
          WRITE(6,*)
          WRITE(6,*) '  WARNING ARRAY SIZE ML EXCEEDED   '
          WRITE(6,*)
          WRITE(6,*) ' ********************************* '
          WRITE(6,*)
          WRITE(6,*)
          STOP
        ENDIF
        WRITE(15,*)
        WRITE(15,*)  ' ********** OUTPUT INFORMATION  ************'
        WRITE(15,*)
        WRITE(15,*) ' OUTPUT AT INTERFACE FOR MATERIAL: ' ,INTOUT(I2)
        WRITE(15,*)
        WRITE(15,*) ' CROSS-SECTIONAL OUTPUT AT STEPS: '
        WRITE(15,*)
        WRITE(15,*) ( IOUT(I2, J), J = 1, NIOUT)
        WRITE(15,*)
 150  CONTINUE
 103  FORMAT( 2X,'    STEP    ',2X,'    TIME    ',2X,'TEMPERATURE',
     $        2X,'AXIAL STRESS',2X,'RADIAL STRESS')
 104  FORMAT( 2X,'    STEP    ',2X,'    TIME    ',2X,'TEMPERATURE',
     $        2X,'AXIAL STRAIN',2X)
      WRITE(15,*)
      WRITE(15,*)
      WRITE(15,*)  ' ********* GEOMETRY INFORMATION  ***********'
      WRITE(15,*)
      READ(11,*) NOMAT
      WRITE(15,*) ' NUMBER OF CELLS ', NOMAT
      WRITE(15,*)
      DO 7  I=1,NOMAT
        READ(11,*)  IMAT(I), VF(I), NODES(I)
        WRITE(15,*) '      FOR CELL NUMBER :', I
        WRITE(15,*)
```

```
        WRITE(15,*) '           MATERIAL NUMBER : ', IMAT(I)
        WRITE(15,*) '           VOLUME FRACTION : ', VF(I)
        WRITE(15,*) '           NODES IN CELL   : ', NODES(I)
        WRITE(15,*)
 7    CONTINUE
 401  CONTINUE
        WRITE(6,*)
        WRITE(6,*)
        WRITE(6,*)  ' PROCEEDING WITH PROBLEM NAMED '
        WRITE(6,*)
        WRITE(6,*)
        WRITE(6,750)  TITLE
        WRITE(6,*)
        WRITE(6,*)
C  ***************************************************
 757  FORMAT(1X,//,' MATERIAL DATA BASE : ',A20,//)
 750  FORMAT( A80 )                   ! FOR TITLES
 755  FORMAT( A30 )                   ! FOR FILE NAMES
 756  FORMAT(1X,//'  LOADING DATA FILE  : ', A20)
 754  FORMAT(1X, I5,  10(1X,1PE12.4))
 781  FORMAT(1X, I4, 10(1X,I8))
      RETURN
      END
C
C =====================================================================
C Readmat
C Read constitutive model type and temperature dependent properties
C For materials defined by the load file.
C This subroutine reads both temperature dependent and independent
C Elastic and inelastic material properties for any constitutive
C Model into material, row, column array tp(i,j,k).
C =====================================================================
C
      SUBROUTINE READMAT( ITYPE )
C
      IMPLICIT DOUBLE PRECISION ( A-H,O-Z )
C
      PARAMETER( LDA = 150, MM = 10, MR = 40, ML = 100, MC = 40 )
      PARAMETER( NN=50)
      COMMON /READM/  NROW(MM,7), NCOL(MM,7), TP(MM,MR,MC),
     $                AT(MM,MR,7), TREF(MM), NSET(MM)
      COMMON /LOAD2/  VF(MM), EZCOOL, IMAT(MM),NODES(MM),
     $                NOMAT, ICASE, ILOAD,ISTRAIN(MM),ISTRAIN2(MM)
      COMMON /NAME1/  NAME(MM), HEADER(MM,7)
      COMMON /STIF / IDAMAGE(10), D(NN), ETA(NN), SPEAK,
```

```
     $               DSM, DSCH, DSCL, DM, DTHETA, DDSTAR, DBETA, DDCH
      INTEGER         ITYPE(MM)
      CHARACTER*80    TITLE, NAME, HEADER
      INTEGER         INROW(7), INCOL(7), INSET, IITYPE
      REAL*8          ZTP(MR,MC), ZAT(MR,7), ZTREF
      CHARACTER*80    ZSTUFF,   ZNAME, ZHEADER(7)
C
C     Go though each material, until you found your data
      DO 410 I = 1, NOMAT
        IMCHECK = IMAT(I)
        REWIND(10)
        READ(10,755) TITLE
        DO 400 IM = 1, 40
          READ(10,755,END=999) ZSTUFF
          READ(10,*,END=999) K, IITYPE
          READ(10,755) ZNAME
C         Read elastic material properties
          READ(10,*) INROW(1)
          INCOL(1)  = 3
          READ(10,755) ZHEADER(1)
          DO 5 IR = 1, INROW(1)
            READ(10,*) ZAT(IR,1),(ZTP(IR,IC),IC=1,INCOL(1))
 5        CONTINUE
          READ(10,*) ZTREF
          IF( IITYPE .NE. 1 ) THEN
C           The inelastic material properties are given in this many sets
            READ(10,*) INSET
            N1 = 1
C           Read the inelastic material properties
            DO 300 IS = 2, INSET + 1
              READ(10,*) INROW(IS), INCOL(IS)
              READ(10,755) ZHEADER(IS)
              N1 = N1 + INCOL(IS-1)
              N2 = N1 + INCOL(IS) - 1
C             If only one row of data then there is no temp variable,
              IF( INROW(IS) .EQ. 1 )THEN
                READ(10,*) (ZTP(1,IC),IC=N1,N2)
              ELSE
C             If properties are temperature dependent,
                DO 7 IR=1,INROW(IS)
                  READ(10,*) ZAT(IR,IS),
     $             ( ZTP(IR,IC),IC=N1,N2 )
  7             CONTINUE
              ENDIF
 300        CONTINUE
```

```
          ENDIF
C         Find new material if material of interest is
C         Not found
          IF(K .EQ. IMCHECK) THEN
C           Store the materials that are used
            ITYPE(I) = IITYPE
            IDAMAGE(I) = 0
C ****** damage in 90 ****************************************
            IF( ITYPE(I) .EQ. 4 )THEN
              IDAMAGE(I) = 1
              ITYPE(I) = 6
            ENDIF
C ************************************************************
            NAME(I) = ZNAME
            NROW(I,1) = INROW(1)
            NCOL(I,1) = INCOL(1)
            HEADER(I,1) = ZHEADER(1)
            DO 9 IR = 1, NROW(I,1)
              AT(I,IR,1) = ZAT(IR,1)
              DO 9 IC = 1, 3
                TP(I,IR,IC) = ZTP(IR,IC)
  9         CONTINUE
            TREF(I) = ZTREF
            IF( ITYPE(I) .NE. 1 ) THEN
C             The inelastic material properties are given in this many sets
              NSET(I) = INSET
              N1 = 1
              DO 310 IS = 2, NSET(I) + 1
                NROW(I,IS) = INROW(IS)
                NCOL(I,IS) = INCOL(IS)
                HEADER(I,IS) = ZHEADER(IS)
                N1 = N1 + NCOL(I,IS-1)
                N2 = N1 + NCOL(I,IS) - 1
C               If only one row of data then there is no temp variable,
                IF( NROW(I,IS) .EQ. 1 )THEN
                  DO 11 IC = N1, N2
                    TP(I,1,IC) = ZTP(1,IC)
  11              CONTINUE
                ELSE
C               If properties are temperature dependent,
                  DO 13 IR=1,NROW(I,IS)
                    AT(I,IR,IS) = ZAT(IR,IS)
                    DO  13 IC = N1, N2
                      TP(I,IR,IC) = ZTP(IR,IC)
  13              CONTINUE
```

```
               ENDIF
 310          CONTINUE
            ENDIF
C           If material type is found and stored, continue
C           With next material
            GOTO 410
          ENDIF
 400    CONTINUE
 410  CONTINUE
      RETURN
C
 999  CONTINUE
      WRITE(6,*)
      WRITE(6,*) ' *************** ERROR *************** '
      WRITE(6,*)
      WRITE(6,*) '   MATERIAL DATA NOT FOUND '
      WRITE(6,*) '   FOR MATERIAL NUMBER  ', IMCHECK
      WRITE(6,*)
      WRITE(6,*) ' *************** ERROR *************** '
      WRITE(6,*)
      WRITE(6,*)
      STOP
C
 755  FORMAT(A80)
      END
C
C=====================================================================
C Newcte
C Compute new cte if reference temperature is not the same as the
C First temperature in the loading file
C=====================================================================
C
      SUBROUTINE NEWCTE( TPROC )
C
      IMPLICIT DOUBLE PRECISION ( A-H,O-Z )
C
      PARAMETER( LDA = 150, MM = 10, MR = 40, ML = 100, MC = 40 )
      PARAMETER( NN = 50)
      COMMON /LOAD2/  VF(MM), EZCOOL, IMAT(MM),NODES(MM),
     $                NOMAT, ICASE, ILOAD,ISTRAIN(MM),ISTRAIN2(MM)
      COMMON  /READM/  NROW(MM,7), NCOL(MM,7), TP(MM,MR,MC),
     $                 AT(MM,MR,7), TREF(MM), NSET(MM)
      REAL*8   CTE(MR), T(MR)

      DO 500 K = 1, NOMAT
```

```
        IF( ABS(TREF(K)-TPROC) .LE. 1.E-6 )GOTO 500
        DO 5  J = 1, NROW(K,1)
          CTE(J) = TP(K,J,3)
          T(J) = AT(K,J,1)
  5     CONTINUE
C       Jfac is used to extrapolate for the new cte at the new ref
C       Due to the fact that the new cte is infinity here.
C       For interpolations between temperatures (general case) jfac=0
C       For cte interpolated a new ref temp from the new cte table =1
        JFAC = 0
C       Compute new secant cte with respect to the initial temperature
C       In the loading file, i. e. tproc.
        J = 1
        TT = TPROC
        DOWHILE(TT.GT.T(J))
          J = J + 1
        ENDDO
C       Determine old cte at processing temperature
        CALL INTERPOL( J, CTE, T, TT, NROW(K,1), CTEPROC, JFAC )
C       Replace the old cte table with the new cte table
        DO 405 J = 1, NROW(K,1)
          XT = T(J)
          XCTE = CTE(J)
          IF(ABS(XT-TT) .LT. 1.E-5 )THEN
            JSTAR = J
            TSTAR = T(J)
            GOTO 405
          ENDIF
C         Compute new cte wrt processing temperature
          TOP = XCTE*(XT-TREF(K)) - CTEPROC*(TPROC - TREF(K))
          CTE(J) = TOP / ( XT - TPROC )
 405    CONTINUE
C       If the new processing temperature is one of the data points
C       Then interpolate between the previous and the next cte.
        IF( ABS(TSTAR-TPROC) .LT. 1.E-5 )THEN
          JFAC = 1
          CALL INTERPOL(JSTAR,CTE,T,TSTAR,NROW,CTE(JSTAR),JFAC)
        ENDIF
        DO 6 J = 1, NROW(K,1)
          TP(K,J,3) = CTE(J)
  6     CONTINUE
        TREF(K) = TPROC
 500  CONTINUE

 755  FORMAT(A80)
```

```
 410  RETURN
      END
C
C =====================================================================
C Closefiles
C Close input files
C =====================================================================
C
      SUBROUTINE CLOSEFILES
C
      IMPLICIT DOUBLE PRECISION ( A-H,O-Z )
C
      REWIND 10
      REWIND 11
      CLOSE(10)
      CLOSE(11)
      RETURN
      END
C
C =====================================================================
C Writemat
C Write material data into output file 15
C =====================================================================
C
      SUBROUTINE WRITEMAT( ITYPE )
C
      IMPLICIT DOUBLE PRECISION ( A-H,O-Z )
C
      PARAMETER( LDA = 150, MM = 10, MR = 40, ML = 100, MC = 40 )
      PARAMETER( NN = 50)
      COMMON  /READM/  NROW(MM,7), NCOL(MM,7), TP(MM,MR,MC),
     $                 AT(MM,MR,7), TREF(MM), NSET(MM)
      COMMON  /NAME1/  NAME(MM), HEADER(MM,7)
      COMMON  /LOAD1/  BT(ML), BSAPP(ML), BTAU(ML),
     $                 BEZ(ML), BSRAPP(ML), NBLOCK(ML),
     $                NCYCLE(ML), NCSTART(ML), NCEND(ML), NCBLOCK
      COMMON /LOAD2/  VF(MM), EZCOOL, IMAT(MM),NODES(MM),
     $                NOMAT, ICASE, ILOAD,ISTRAIN(MM),ISTRAIN2(MM)
      COMMON /STIF / IDAMAGE(10), D(NN), ETA(NN), SPEAK,
     $               DSM, DSCH, DSCL, DM, DTHETA, DDSTAR, DBETA, DDCH
      INTEGER          ITYPE(MM)
      CHARACTER*80    NAME, HEADER
C
      WRITE(6,*)
      WRITE(6,*) ' ENTER: (1) FOR MATERIAL PROPERTY OUTPUT '
```

```
 WRITE(6,*) '        (2) FOR NO MATERIAL PROPERTY OUTPUT '
 WRITE(6,*)
 READ(5,*) IMATOUT
 WRITE(6,*)
 WRITE(6,*)
 WRITE(6,*) ' ****************************************'
 WRITE(6,*)
 WRITE(6,*)  ' PROCEEDING WITH PROBLEM - PLEASE STAND BY '
 WRITE(6,*)
 WRITE(6,*) ' ****************************************'
 WRITE(6,*)
 WRITE(6,*)
 WRITE(15,*)
 WRITE(15,*)
 WRITE(15,*)  ' ********** MATERIAL INFORMATION  ************'
 WRITE(15,*)
 DO 400 K = 1, NOMAT
   WRITE(15,*)
   WRITE(15,*)   ' MATERIAL FOR CELL NUMBER : ', K
   WRITE(15,*)
   WRITE(15,755) NAME(K)
   WRITE(15,*)
   IF( ITYPE(K) .EQ. 1 )THEN
     WRITE(15,*) ' CONSTITUTIVE MODEL: ELASTIC '
   ELSEIF( ITYPE(K) .EQ. 2 )THEN
     WRITE(15,*) ' CONSTITUTIVE MODEL: BILINEAR ELASTIC-PLASTIC '
   ELSEIF( ITYPE(K) .EQ. 3 )THEN
     WRITE(15,*)
$    ' CONSTITUTIVE MODEL: ELASTIC-PLASTIC WITH DAMAGE '
   ELSEIF( ITYPE(K) .EQ. 4 )THEN
     WRITE(15,*) ' CONSTITUTIVE MODEL: VISCO-PLASTIC WITH DAMAGE '
   ELSEIF( ITYPE(K) .EQ. 5 )THEN
     WRITE(15,*)
$    ' CONSTITUTIVE MODEL: BODNER-PARTOM WITH BACK STRESS '
   ELSEIF( ITYPE(K) .EQ. 6 )THEN
     WRITE(15,*)
$    'CONSTITUTIVE MODEL: BODNER-PARTOM WITH DIRECTIONAL HARDENING'
   ENDIF
   IF( IMATOUT .NE. 1 ) GOTO 400
   WRITE(15,*)
   WRITE(15,*)
   WRITE(15,*)  ' ---------- MATERIAL PROPERTIES  ---------- '
   WRITE(15,*)
   NCOL(K,1) = 3
   DO 300 IS = 1, NSET(K)+1
```

```
          WRITE(15,*)
          WRITE(15,755) HEADER(K,IS)
          IF( IS. EQ. 1 ) THEN
            N1 = 0
          ELSE
            N1 = N1+NCOL(K,IS-1)
          ENDIF
          N2 = NCOL(K,IS)
          IF( NROW(K,IS). EQ. 1 .AND. IS .NE. 1 ) THEN
            WRITE(15,*) ( TP(K,1,L), L=N1+1,N1+N2 )
          ELSE
            DO 5 J = 1,NROW(K,IS)
              WRITE(15,754) AT(K,J,IS), (TP(K,J,L), L=N1+1,N1+N2)
  5         CONTINUE
          ENDIF
          IF( IS .EQ. 1 ) THEN
            WRITE(15,*)
            WRITE(15,*) ' REFERENCE TEMPERATURE = ',  TREF(K)
C           If(itype(k) .ne. 1) write(15,*) 'set no: ',nset(k)
          ENDIF
          WRITE(15,*)  ' ---------------------------------------- '
          IF( ITYPE(K) .EQ. 1 ) GOTO 400
 300    CONTINUE
 400  CONTINUE
      WRITE(15,*)
 754  FORMAT(10(1X,1PE12.4))
 755  FORMAT(A80)
      RETURN
      END
C
C =====================================================================
C Load
C Interpolate for applied loading, time and temperature
C Compute increments in temperature, applied stress, total applied
C Strain and time
C =====================================================================
C
      SUBROUTINE LOAD( IB, NSTEPS,  STEP, TPROC )
C
      IMPLICIT DOUBLE PRECISION ( A-H,O-Z )
C
      PARAMETER( LDA = 150, MM = 10, MR = 40, ML = 100, MC = 40 )
      PARAMETER( NN = 50)
      COMMON /LOAD1/  BT(ML), BSAPP(ML), BTAU(ML),
     $                BEZ(ML), BSRAPP(ML), NBLOCK(ML),
```

```
     $                NCYCLE(ML), NCSTART(ML), NCEND(ML), NCBLOCK
      COMMON /LOADT/  T, SZ, EZ, SR, TAU, DT,
     $                TINCR, SZINCR, EZINCR, SRINCR, DTAU,
     $                TIME, ICYCLE, IBLOCK
      COMMON /ELASX/ TEO(NN),TE(NN),TNU(NN),TCTE(NN),ECOM,CTECOM
      COMMON /CCM1 /  RAD(LDA), IBEG(MM), IEND(MM), NTOT
      COMMON /MATRIX/ AMAT(LDA,LDA), BMAT(LDA), NRA,
     $                IPVT(LDA)
      COMMON /MATRIX2/ AA(NN), BB(NN), CC(NN), DD(NN),
     $                FF(NN), GG(NN), HH(NN), QQ(NN), PP(NN)
c
      T    = T   + TINCR
      DT   = T   - TPROC
      SZ   = SZ  + SZINCR
      SR   = SR  + SRINCR
      EZ   = EZ  + EZINCR
      TAU  = TAU + DTAU
      TIME = TIME + DTAU
c
c
      DO 100 I = 2, NTOT
        QQ(I) = TE(I)*DT*(TCTE(I)*(1 + TNU(I))
     $    - TCTE(I-1)*(1 + TNU(I-1))      )
 100  CONTINUE
      DO 20 I = 1, NRA
        BMAT(I) = 0.0
 20   CONTINUE
C     If radial loading is applied, add term in b(ntot-1)
      BMAT(NTOT-1) = SR
      RETURN
      END
C =====================================================================
      FUNCTION XNEW( STEP, NSTEPS, X1, X2 )
C
      IMPLICIT DOUBLE PRECISION ( A-H,O-Z )
C
      xsteps = nsteps
      XNEW = STEP*( X2 - X1 )/xsteps + X1
      RETURN
      END
C
C =====================================================================
C Subcut
C =====================================================================
C
```

```
      SUBROUTINE SUBCUT(ITYPE,IB,NSTEPS,ISTEP)
C
      IMPLICIT DOUBLE PRECISION ( A-H,O-Z )
C
      PARAMETER( LDA = 150, MM = 10, MR = 40, ML = 100, MC = 40 )
      PARAMETER( NN = 50)
      COMMON /LOAD1/  BT(ML), BSAPP(ML), BTAU(ML),
     $                BEZ(ML), BSRAPP(ML), NBLOCK(ML),
     $                NCYCLE(ML), NCSTART(ML), NCEND(ML), NCBLOCK
      COMMON /LOAD2/  VF(MM), EZCOOL, IMAT(MM),NODES(MM),
     $                NOMAT, ICASE, ILOAD,ISTRAIN(MM),ISTRAIN2(MM)
      COMMON /CCM1 /  RAD(LDA), IBEG(MM), IEND(MM), NTOT
      COMMON /ELASX/ TEO(NN),TE(NN),TNU(NN),TCTE(NN),ECOM,CTECOM
      COMMON /LOADT/  T, SZ, EZ, SR, TAU, DT,
     $                TINCR, SZINCR, EZINCR, SRINCR, DTAU,
     $                TIME, ICYCLE, IBLOCK
      COMMON  /PROP/   P(MM,MC)
      COMMON /CONTROL/ TOLER1, TOLER2, RELAX, FAST, ICOUNT,
     $                 ISUBTOT, IZMAX, MAXITER
      INTEGER          ITYPE(MM)
C
C Set control variables
C
      IF (ICASE .NE. 2) THEN
        TOLER1 = 0.01
        TOLER2 = 0.01
      ELSE
        TOLER1 = 0.0001
        TOLER2 = 0.0001
      END IF
      RELAX  = 0.5
      IZMAX   = 30
      MAXITER = 30
C
      STEP    = ISTEP
      TNEW    = XNEW( STEP, NSTEPS, BT(IB), BT(IB+1) )
      SZNEW   = XNEW( STEP, NSTEPS, BSAPP(IB), BSAPP(IB+1) )
      EZNEW   = XNEW( STEP, NSTEPS, BEZ(IB), BEZ(IB+1) )
      SRNEW   = XNEW( STEP, NSTEPS, BSRAPP(IB), BSRAPP(IB+1) )
      TAUNEW  = XNEW( STEP, NSTEPS, BTAU(IB), BTAU(IB+1) )
      CALL PROPT( ITYPE, TNEW )
      ECOM = 0.0
      CTECOM = 0.0
C     Elastic properties at the nodes
      DO 100 IM = 1, NOMAT
```

```
        DO 200 K = IBEG(IM), IEND(IM)
        IF(ITYPE(IM) .GE. 5) ISUBTOT = 1 + FAST* P(IM,4)
 200    CALL ELAS( IM, K )
C       Compute composite modulus and composite cte
        K = IBEG(IM)
        ECOM = ECOM + TE(K)*VF(IM)
        CTECOM = CTECOM + TCTE(K)*TE(K)*VF(IM)
 100  CONTINUE
c
      TINCR  = (TNEW - T)/FLOAT(ISUBTOT)
      SZINCR = (SZNEW - SZ)/FLOAT(ISUBTOT)
      SRINCR = (SRNEW - SR)/FLOAT(ISUBTOT)
      EZINCR = (EZNEW - EZ)/FLOAT(ISUBTOT)
      DTAU   = (TAUNEW - TAU)/FLOAT(ISUBTOT)
c
      IF(ICOUNT .GT. 1 .AND. TINCR .LE. 1.E-6) RETURN
      IF(ICASE .NE. 2) THEN
      CALL AMATRIX( ICOUNT )
      ENDIF
      RETURN
      END
C
C =====================================================================
C Propt
C Interpolate for material properties at temperature t
C =====================================================================
C
      SUBROUTINE PROPT( ITYPE, T )
C
      IMPLICIT DOUBLE PRECISION ( A-H,O-Z )
C
      PARAMETER( LDA = 150, MM = 10, MR = 40, ML = 100, MC = 40 )
      PARAMETER( NN = 50)
      COMMON /LOAD2/  VF(MM), EZCOOL, IMAT(MM),NODES(MM),
     $                NOMAT, ICASE, ILOAD,ISTRAIN(MM),ISTRAIN2(MM)
      COMMON  /READM/  NROW(MM,7), NCOL(MM,7), TP(MM,MR,MC),
     $                 AT(MM,MR,7), TREF(MM), NSET(MM)
      COMMON  /PROP/   P(MM,MC)
      INTEGER          ITYPE(MM)
C
      DO 400 I = 1, NOMAT
        N1 = 0
        DO 400 L = 1, NSET(I)+1
          N1 = N1 + NCOL(I,L-1)
          N2 = NCOL(I,L)
```

```
          IF( NROW(I,L) .EQ. 1 )THEN
            DO 200 K = 1+N1, N1+N2
              IF( TP(I,1,K) .LE. -9990)THEN
                ID_CUR = IFIX( TP(I,1,K))
                P(I,K) = CURVE(T,ID_CUR)
                GOTO 200
              ENDIF
              P(I,K) = TP(I,1,K)
 200        CONTINUE
          ELSE
            DO 5  J = 1, NROW(I,L)
              IF( T .LE. AT(I,J,L) ) GOTO 20
  5         CONTINUE
            J = J - 1
 20         DO 205 K = 1+N1, N1+N2
              IF( TP(I,1,K) .LE. -9990 )THEN
                ID_CUR = IFIX( TP(I,1,K))
                P(I,K) = CURVE(T,ID_CUR)
                GOTO 205
              ENDIF
              CALL INTER( I, J, K, L, T )
CXx           write(15,*) i, k, p(i,k)
 205        CONTINUE
          ENDIF
 400  CONTINUE
      RETURN
      END
C =====================================================================
C Functional properties
C Material properties given as an explicit function of temperature
C =====================================================================
      FUNCTION CURVE(T,ID_CUR)
C
      IMPLICIT DOUBLE PRECISION ( A-H,O-Z )
C
      PARAMETER( LDA = 150, MM = 10, MR = 40, ML = 100, MC = 40 )
      PARAMETER( NN = 50)
C
C     This is specifically for fuctionally defined properties
      CURVE = 0
      IF(ID_CUR .EQ. -9999) THEN
        CURVE = 5.8E5*EXP( -1.37E4/(T+273) )
      ENDIF
      RETURN
      END
```

```
C
C ======================================================================
C Propnodes
C Assign material properties to nodes and multiply by appropriate const
C ======================================================================
C
      SUBROUTINE PROPNODES( ITYPE, ICOUNT )
C
      IMPLICIT DOUBLE PRECISION ( A-H,O-Z )
C
      PARAMETER( LDA = 150, MM = 10, MR = 40, ML = 100, MC = 40 )
      PARAMETER(NN=50)
      COMMON  /PROP / P(MM,MC)
      COMMON /CCM1 /  RAD(LDA), IBEG(MM), IEND(MM), NTOT
      COMMON /LOAD2/  VF(MM), EZCOOL, IMAT(MM),NODES(MM),
     $                NOMAT, ICASE, ILOAD,ISTRAIN(MM),ISTRAIN2(MM)
      COMMON /ELASX/ TEO(NN),TE(NN),TNU(NN),TCTE(NN),ECOM,CTECOM
      COMMON  /MAT2A/ TSY(NN), TEP(NN)
      COMMON  /MAT5A/ TN(NN), TZ0(NN), TF1(NN), TF3(NN),
     $                TBSMAX(NN),  TD0(NN)
      COMMON /MAT6A/  TND(NN), TZ0D(NN), TZ3(NN), TM2(NN),
     $                TA1(NN), TM1(NN), TZ1(NN), TR1(NN),
     $                TR2(NN), TD0D(NN), TZ2(NN),
     $                DTZ1(NN), DTZ2(NN), DTZ3(NN)
      COMMON /STIF / IDAMAGE(10), D(NN), ETA(NN), SPEAK,
     $               DSM, DSCH, DSCL, DM, DTHETA, DDSTAR, DBETA, DDCH
      INTEGER         ITYPE(MM)
C
      ECOM = 0.0
      CTECOM = 0.0
C     Elastic properties at the nodes
      DO 100 IM = 1, NOMAT
        DO 200 K = IBEG(IM), IEND(IM)
 200      CALL ELAS( IM, K )
C       Compute composite modulus and composite cte
        K = IBEG(IM)
        ECOM = ECOM + TE(K)*VF(IM)
        CTECOM = CTECOM + TCTE(K)*TE(K)*VF(IM)
 100  CONTINUE
      IF(ECOM .EQ. 0) THEN
        WRITE(6,*) ' COMPOSITE MODULUS ERROR '
        WRITE(6,*) ' DOUBLE CHECK YOUR INPUT FILE '
        STOP
      ENDIF
      CTECOM = CTECOM/ECOM
```

```
C     Inelastic properties at the nodes
      DO 300 IM = 1, NOMAT
        IF( ITYPE(IM) .EQ. 1 ) THEN
          GOTO 300
        ELSEIF( ITYPE(IM) .EQ. 2 ) THEN
          DO 10  K = IBEG(IM),IEND(IM)
            CALL MAT2( IM, K )
 10       CONTINUE
        ELSEIF( ITYPE(IM) .EQ. 3 ) THEN
          DO 15  K = IBEG(IM),IEND(IM)
            CALL MAT2( IM, K )
 15       CONTINUE
        ELSEIF( ITYPE(IM) .EQ. 4 ) THEN
C         Bodner-partom with direct hard with damage
C         Is automatically redefined as itype=6 and
C         Idamage(im) = 1
        ELSEIF( ITYPE(IM) .EQ. 5 ) THEN
          DO 20   K = IBEG(IM), IEND(IM)
            CALL MAT5( IM, K, ICOUNT )
 20       CONTINUE
        ELSEIF( ITYPE(IM) .EQ. 6 ) THEN
          DO 25   K = IBEG(IM),IEND(IM)
            CALL MAT6( IM, K, ICOUNT )
 25       CONTINUE
        ELSEIF( ITYPE(IM) .EQ. 7 ) THEN
          DO 30   K = IBEG(IM),IEND(IM)
            CALL MAT7( IM, K, ICOUNT )
 30       CONTINUE
        ENDIF
 300  CONTINUE
      RETURN
      END
C
C =====================================================================
C Amatrix
C For concentric cylinder model case, create a-matrix and the l-u
C Decomposition at this loading step
C =====================================================================
C
      SUBROUTINE AMATRIX( ICOUNT )
C
      IMPLICIT DOUBLE PRECISION ( A-H,O-Z )
C
      PARAMETER( LDA = 150, MM = 10, MR = 40, ML = 100, MC = 40 )
      PARAMETER( NN = 50)
```

```
      COMMON /LOADT/  T, SZ, EZ, SR, TAU, DT,
     $                TINCR, SZINCR, EZINCR, SRINCR, DTAU,
     $                TIME, ICYCLE, IBLOCK
      COMMON /LOAD2/  VF(MM), EZCOOL, IMAT(MM),NODES(MM),
     $                NOMAT, ICASE, ILOAD,ISTRAIN(MM),ISTRAIN2(MM)
      COMMON /ELASX/ TEO(NN),TE(NN),TNU(NN),TCTE(NN),ECOM,CTECOM
      COMMON /CCM1 /  RAD(LDA), IBEG(MM), IEND(MM), NTOT
      COMMON /MATRIX/ AMAT(LDA,LDA), BMAT(LDA), NRA,
     $                IPVT(LDA)
      COMMON /MATRIX2/ AA(NN), BB(NN), CC(NN), DD(NN),
     $                FF(NN), GG(NN), HH(NN), QQ(NN), PP(NN)

      IF( ICASE .EQ. 3) THEN
        NTOT = NTOT - 2
        NOMAT = NOMAT - 1
      ENDIF
      NRA = 2*( NTOT - 1 )
CFcb  changed nn to ntot
      DO 10 I = 1, NTOT
        AA(I) = 0.0
        BB(I) = 0.0
        CC(I) = 0.0
        DD(I) = 0.0
        FF(I) = 0.0
        GG(I) = 0.0
        HH(I) = 0.0
 10   CONTINUE
      DO 20 I = 1, NRA
        DO 20 J = 1, NRA
          AMAT(I,J) = 0.0
 20   CONTINUE
      DO 30 I = 2, NTOT
CJoe    aa(i) = ( rad(i) - rad(i-1) )/(rad(i) + rad(i-1))
        AA(I) = 0.5*( RAD(I) - RAD(I-1) )/RAD(I)
        BB(I) = TE(I) / TE(I-1)
        CC(I) = RAD(I) / RAD(I-1)
        DD(I) = ( 1 + TNU(I) )*( TNU(I) + AA(I) )
        FF(I) = ( 1 + TNU(I) )*( 1 - TNU(I) + AA(I) )
        GG(I) = ( 1 + TNU(I-1) )*( TNU(I-1) - AA(I)*CC(I) )*BB(I)
        HH(I) = ( 1 + TNU(I-1) )*( 1 - TNU(I-1) - AA(I)*CC(I) )
     $    *BB(I)
 30   CONTINUE

C     The limits are taken for the first terms in left submatrices
      AMAT(1,1) = AA(2)
```

```
      AMAT(NTOT,1) = (1 + TNU(1))*(1 - 2*TNU(1))*BB(2)
      DO 50 I = 2, NTOT - 1
C       Upper left submatrix (without the first term)
        AMAT(I-1,I) = -1.0
        AMAT(I,I) = 1/CC(I+1)
C       Lower left submatrix (without the first term)
        AMAT(NTOT+I-2,I) = DD(I)
        AMAT(NTOT+I-1,I)  = -GG(I+1)
C       Lower diagonal terms in the upper right submatrix
        AMAT(I,NTOT+I-2) = AA(I+1)
C       Lower diagonal terms in the lower right submatrix
        AMAT(NTOT+I-1,NTOT+I-2) = HH(I+1)
 50   CONTINUE
C     Skip the addition to the amatrix during strain loading
      IF( ILOAD .EQ. 1 )GOTO 55
CC - -add additional terms at equations for interface nodes
      DO 11  I = 2,NOMAT
        J = IEND(I-1)
        AMAT(NTOT-1+J,J) = - GG(J+1) + 2*TE(J+1)/ECOM*VF(I-1)
     $    *( TNU(J) - TNU(J+1) )**2
 11   CONTINUE
 55   DO 60 I=1,NTOT-1
C       Upper right submatrix diagonal
        AMAT(I,NTOT+I-1) = AA(I+1)
C       Lower right submatrix diagonal
        AMAT(NTOT+I-1,NTOT+I-1) = -FF(I+1)   ! LOWER RIGHT
 60   CONTINUE
C     Compute the lu factorization of amat and store in amat
      CALL LUDCMP(AMAT,NRA,LDA,IPVT,D)
      IF( ICASE .EQ. 3 ) THEN
        NTOT = NTOT + 2
        NOMAT = NOMAT + 1
      ENDIF
      RETURN
      END
C
C =====================================================================
C Stress
C Compute stresses assuming elastic behavior for the last load incr.
C =====================================================================
C
      SUBROUTINE STRESS( EP, ICOUNT )
C
      IMPLICIT DOUBLE PRECISION ( A-H,O-Z )
C
```

```
      PARAMETER( LDA = 150, MM = 10, MR = 40, ML = 100, MC = 40 )
      PARAMETER( NN = 50)
      COMMON /LOADT/  T, SZ, EZ, SR, TAU, DT,
     $                TINCR, SZINCR, EZINCR, SRINCR, DTAU,
     $                TIME, ICYCLE, IBLOCK
      COMMON /STIF / IDAMAGE(10), D(NN), ETA(NN), SPEAK,
     $               DSM, DSCH, DSCL, DM, DTHETA, DDSTAR, DBETA, DDCH
      COMMON /LOAD2/  VF(MM), EZCOOL, IMAT(MM),NODES(MM),
     $                NOMAT, ICASE, ILOAD,ISTRAIN(MM),ISTRAIN2(MM)
      COMMON /ELASX/ TEO(NN),TE(NN),TNU(NN),TCTE(NN),ECOM,CTECOM
      COMMON /CCM1 /  RAD(LDA), IBEG(MM), IEND(MM), NTOT
      COMMON /MATRIX/ AMAT(LDA,LDA), BMAT(LDA), NRA,
     $                IPVT(LDA)
      COMMON /MATRIX2/ AA(NN), BB(NN), CC(NN), DD(NN),
     $                FF(NN), GG(NN), HH(NN), QQ(NN), PP(NN)
      COMMON /STRES/  S(6,NN), SDEV(6,NN),
     $                SEFF(NN), SE(NN), SEFFOLD(NN)
      COMMON /STRAI/  ETOT(6,NN), DEP(6,NN), EME(6,NN), ETH(NN),
     $                DEFF(NN), EPEFF(NN), DEPOLD(6,NN)
      REAL*8              EP(6,NN)
C
C *********** damage for 90, stiffness reduction ********************
      DO 9 I=1,NOMAT
        IF( IDAMAGE(I) .EQ. 1 )THEN
          DO 8 J = IBEG(I), IEND(I)
  8         TE(J) = TEO(J)*(1.0-ETA(J)*D(J))
        ENDIF
 9    CONTINUE
C     Compute new composite modulus and cte
      ECOM = 0.0
      CTECOM = 0.0
      DO I=1,NOMAT
        J = IBEG(I)
        ECOM = ECOM + TE(J)*VF(I)
        CTECOM = CTECOM + TCTE(J)*TE(J)*VF(I)
      ENDDO
      CTECOM = CTECOM/ECOM
C ********************************************************************
      GOTO(10,20,30), ICASE
C     For icase 1 - concentric cylinder
 10   CALL STRESS1( EP, ICOUNT )
      GO TO 99
C     For icase 2 - lamina model
 20   CALL STRESS2( EP, ICOUNT )
      GO TO 99
```

```
C     For icase 3 - concentric cylinder with [90]
 30   CALL STRESS3( EP, ICOUNT )
 99   CONTINUE
      DO 3  J = 1, NTOT
C       Compute total strains
        ETOT(1,J) = ( S(1,J) - TNU(J)*( S(2,J) + S(3,J) ) ) / TE(J)
     $    + TCTE(J)*DT + EP(1,J)
        ETOT(2,J) = ( S(2,J) - TNU(J)*( S(1,J) + S(3,J) ) ) / TE(J)
     $    + TCTE(J)*DT + EP(2,J)
        ETOT(3,J) = ( S(3,J) - TNU(J)*( S(1,J) + S(2,J) ) ) / TE(J)
     $    + TCTE(J)*DT + EP(3,J)
        ETH(J) = TCTE(J)*DT
        DO 1 I = 1, 3
          EME(I,J) = ETOT(I,J) - ETH(J)
  1     CONTINUE
        CALL DEVIATS( J )
        SEFF(J) = CSEFF( J )
  3   CONTINUE
      RETURN
      END
C
C =====================================================================
C Output1, called from inelastic
C Print output
C =====================================================================
C
      SUBROUTINE OUTPUT1( ICOUNT, ITYPE, EP, BS )
C
      IMPLICIT DOUBLE PRECISION ( A-H,O-Z )
C
      PARAMETER( LDA = 150, MM = 10, MR = 40, ML = 100, MC = 40 )
      PARAMETER( NN = 50)
      COMMON /LOADO/  INTOUT(ML),IOUT(ML,20),
     $                IPRINTSTEP(ML),ISTEPOUT(ML)
      COMMON /STRES/  S(6,NN), SDEV(6,NN),
     $                SEFF(NN), SE(NN), SEFFOLD(NN)
      COMMON /STRAI/  ETOT(6,NN), DEP(6,NN), EME(6,NN), ETH(NN),
     $                DEFF(NN), EPEFF(NN), DEPOLD(6,NN)
      COMMON /ELASX/ TEO(NN),TE(NN),TNU(NN),TCTE(NN),ECOM,CTECOM
      COMMON /MAT2A/  TSY(NN), TEP(NN)
      COMMON /STIF / IDAMAGE(10), D(NN), ETA(NN), SPEAK,
     $               DSM, DSCH, DSCL, DM, DTHETA, DDSTAR, DBETA, DDCH
      COMMON /CCM1 /  RAD(LDA), IBEG(MM), IEND(MM), NTOT
      COMMON /LOAD2/  VF(MM), EZCOOL, IMAT(MM),NODES(MM),
     $                NOMAT, ICASE, ILOAD,ISTRAIN(MM),ISTRAIN2(MM)
```

```
      COMMON /LOADT/  T, SZ, EZ, SR, TAU, DT,
     $                TINCR, SZINCR, EZINCR, SRINCR, DTAU,
     $                TIME, ICYCLE, IBLOCK
      COMMON /MAT6B/  BETA(6,NN),ZD(NN),ZI(NN),ZTOT(NN)
      REAL*8          BS(6,NN), EP(6,NN), DUM1(10), OUTVAR(30)
      INTEGER         ITYPE(MM)
      CHARACTER*10 REAL10
C
C Compute effective stress which is not computed for elastic runs
      IF( ICOUNT .EQ. 0 ) THEN
        WRITE(15,699)
 699    FORMAT(//,2X,
     $  '-------------------- OUTPUT -------------------',//)
        IF( ICASE .EQ. 1 ) WRITE(15,110)
        IF( ICASE .EQ. 2 ) WRITE(15,210)
        IF( ICASE .EQ. 3 ) WRITE(15,310)
        IF( ICASE .NE. 2 ) WRITE(16,410)
      ENDIF
C=====================================================================
 110  FORMAT(' BLOCK  CYCLE  ','  TIME  ',3X,'TEMPERATRE',
     $       3X,'  SEFF  ',3X,'  SRAD  ',3X,'  STAN  ',
     $       3X,'   SZ   ',3X,' EPRAD  ',3X,' EPTAN  ',
     $       3X,'  EPZ   ',3X,'   ZI   ',3X,'   ZD   ')
C=====================================================================
 210  FORMAT(' BLOCK  CYCLE  STEP  ','    TIME   ',3X,'TEMPERATRE ',
     $       3X,'  SZ-APP   ',3X,'  SZ-LAM1  ',3X,'  SZ-LAM2   ',
     $       3X,'  SZ-LAM3  ',3X,'   ETOT    ',3X,' EME-LAM1   ')
C    $       3x,' eme-lam2  ',3x,' eme-lam3  ')
C=====================================================================
 310  FORMAT(' BLOCK  CYCLE  STEP  ','    TIME   ',3X,'TEMPERATRE ',
     $       3X,'    SEFF   ',3X,'    SRAD   ',3X,'    STAN   ',
     $       3X,'     SZ    ',3X,'    ERAD   ',3X,'    ETAN   ',
     $       3X,'     EZ    ')
C=====================================================================
 410  FORMAT(' BLOCK  CYCLE  STEP  ','    TIME   ',3X,'TEMPERATRE ',
     $       3X,'    SZAPP  ',3X,'    SZF    ',3X,'    SZM    ',
     $       3X,'     SZ90  ',3X,'    EME-F  ',3X,'   EME-M   ',
     $       3X,'    EME-90 ',3X,'    EZC    ' )
C=====================================================================
C     This is for summing loads for the [0/90] model
      IF( ILOAD .EQ. 1 ) THEN
        IF( ICASE .EQ. 1 ) THEN
          SZ = 0.0
          DO 6  I = 2, NTOT
            SZ = SZ + (RAD(I)**2-RAD(I-1)**2)*0.5*(S(3,I)+S(3,I-1))
```

```
  6       CONTINUE
        ELSEIF(ICASE .EQ. 2) THEN
          SZ = 0.0
          DO 7 I = 1, NOMAT
            SZ = SZ + VF(I) * S(3,I)
  7       CONTINUE
        ELSEIF(ICASE .EQ. 3) THEN
          SZ = 0.0
          DO 8 I = 1, NOMAT-2
            SZ = SZ + (RAD(I)**2-RAD(I-1)**2)*0.5*(S(3,I)+S(3,I-1))
  8       CONTINUE
          SZ = SZ + VF(NOMAT) * S(3,NOMAT)
        ENDIF
      ENDIF
C=======================================================================
C
C File 15            t h e   x - f i l e
C
C=======================================================================
C
C     Concentric cylinder model
      IF(ICASE .EQ. 1) THEN
        IO = IBEG(INTOUT(IBLOCK))
        OUTVAR(1)  = TIME
        OUTVAR(2)  = T
        OUTVAR(3)  = SEFF(IO)
        OUTVAR(4)  = S(1,IO)
        OUTVAR(5)  = S(2,IO)
        OUTVAR(6)  = S(3,IO)
        OUTVAR(7)  = EP(1,IO)
        OUTVAR(8)  = EP(2,IO)
        OUTVAR(9)  = EP(3,IO)
        OUTVAR(10) = ZI(IO)
        OUTVAR(11) = ZD(IO)
c        WRITE(15,213) IBLOCK, ICYCLE, ( OUTVAR(J), J=1,11 )
         write(15,212) iblock, icycle, (real10(outvar(j)), j=1,11)
 212    FORMAT(2(1X,I5),  11(1X, A10 ))
 213    FORMAT(2(1X,I5),  11(1X, 1PE15.8 ))
      ENDIF
C=======================================================================
C
C  Lamina model
C
C=======================================================================
      IF(ICASE .EQ. 2 ) THEN
```

```
        OUTVAR(1)  = TIME                  ! TIME
        OUTVAR(2)  = T                     ! TEMPERAUTE
        OUTVAR(3)  = SZ                    ! APPLIED STRESS
        OUTVAR(4)  = S(3,1)
        OUTVAR(5)  = S(3,2)
        OUTVAR(6)  = S(3,3)
        OUTVAR(7)  = ETOT(3,1)             ! TOTAL Z-STRAIN
        OUTVAR(8)  = EME(3,1)
        OUTVAR(9)  = EME(3,2)
        OUTVAR(10) = EME(3,3)
        OUTVAR(11) = ZD(IBEG(INTOUT(IBLOCK)))
        OUTVAR(12) = ZI(IBEG(INTOUT(IBLOCK)))
C       Outvar(6)  = ep(3,1)
        WRITE(15,211) IBLOCK, ICYCLE, ICOUNT, ( OUTVAR(J), J=1,12 )
 211    FORMAT(2(1X,I5), 1X,I8, 12(1X,1PE15.8) )
      ENDIF
C=======================================================================
C
C       Concentric cyclinder with parallel [90] ply
C
C=======================================================================
      IF(ICASE .EQ. 3) THEN
        IO = IBEG(INTOUT(IBLOCK))
        OUTVAR(1)  = TIME
        OUTVAR(2)  = T
        OUTVAR(3)  = SEFF(IO)
        OUTVAR(4)  = S(1,IO)
        OUTVAR(5)  = S(2,IO)
        OUTVAR(6)  = S(3,IO)
        OUTVAR(7)  = EME(1,IO)
        OUTVAR(8)  = EME(2,IO)
        OUTVAR(9)  = EME(3,IO)
        OUTVAR(10) = EP(1,IO)
        OUTVAR(12) = EP(2,IO)
        OUTVAR(11) = EP(3,IO)
        WRITE(15,211) IBLOCK, ICYCLE, ICOUNT, ( OUTVAR(J), J=1,9 )
      ENDIF
C=======================================================================
C
C File 16           t h e   y - f i l e
C
C=======================================================================
C
      IF( ICASE .NE. 2 )  THEN
        OUTVAR(1) = TIME                ! TIME
```

```
        OUTVAR(2) = T                     ! TEMPERATURE
        OUTVAR(3) = SZ                    ! APPLIED STRESS
        OUTVAR(4) = S(3,IEND(1))    ! FIBER Z-STRESS
        OUTVAR(6) = S(3,IEND(3))    ! [90] Z-STRESS
        D5 = OUTVAR(3) - OUTVAR(4)*VF(1)
     $    - OUTVAR(6)*VF(3)  ! AVE MATRIX Z-STRESS
        OUTVAR(5) = D5/VF(2)              !   FOR F/M/90
        OUTVAR(7) = EME(3,IEND(1))       ! EZMECH IN FIBER
        OUTVAR(8) = EME(3,IEND(2))       ! EZMECH IN MATR
        OUTVAR(9) = EME(3,IEND(3))       ! EZMECH IN [90]
        OUTVAR(10) = ETOT(3,1)            ! TOTAL Z-STRAIN
        OUTVAR(11) = ETOT(3,1)-CTECOM*DT  ! COMPOSITE EZMECH
        OUTVAR(12) = EP(3,IEND(2)+1)       ! EZP @ MATRIX INT
        OUTVAR(13) = EP(3,IEND(3)+1)       ! EZP IN [90]
        OUTVAR(14) = S(3,IEND(2))  ! Z-STRESS@MATR/INT
        WRITE(16,211) IBLOCK, ICYCLE, ICOUNT,(OUTVAR(K), K = 1, 10)
      ENDIF
C=====================================================================
C
C File 17           t h e   z - f i l e
C
C=====================================================================
C Print stresses and plastic strains at the x-section for step iout
C
      IF(ICASE .NE. 2) THEN
        DO 4 KOUT = 1, 10
          IF( ICOUNT .EQ. IOUT(IBLOCK,KOUT) .AND.
     $    ICOUNT .GT. 0 )THEN
            WRITE(17,509) ICYCLE, IBLOCK, ICOUNT, TIME
            WRITE(17,510)
            DO 45 I = 1, NTOT
              DO 3  K = 1, 3
                DUM1(K) = S(K,I)
                DUM1(K+3) = EME(K,I)
  3           CONTINUE
              SDUM = SEFF(I)
              WRITE(17,511) RAD(I), SDUM, ( DUM1(K), K = 1, 6 )
 45         CONTINUE
          ENDIF
 4      CONTINUE
      ENDIF
C                           Formats -------------------------------
 509  FORMAT(//, 2X,' CROSS-SECTIONAL RESULTS AT CYCLE ', I5,/,
     $           2X,'                           BLOCK ', I5,/,
     $           2X,'                           STEP  ', I5,/,
```

```
     $           2X,'   TIME = ', F15.4,//)
 510  FORMAT( 3X,'   RADIUS  ',2X,'    SEFF   ',3X,'    SRAD   ',
     $        3X,'   STAN    ',3X,'     SZ    ',3X,'     ER    ',
     $        3X,'   ETAN    ',3X,'     EZ    ')
 511  FORMAT(2X, F12.3, 10(2X,1PE12.4) )
C
      RETURN
      END
C
C =====================================================================
C Stress2
C  Solves stress state for 1-d lamina model
C =====================================================================
C
      SUBROUTINE STRESS2( EP, ICOUNT )
C
      IMPLICIT DOUBLE PRECISION ( A-H,O-Z )
C
      PARAMETER( LDA = 150, MM = 10, MR = 40, ML = 100, MC = 40 )
      PARAMETER( NN = 50)
      COMMON /LOADT/  T, SZ, EZ, SR, TAU, DT,
     $                TINCR, SZINCR, EZINCR, SRINCR, DTAU,
     $                TIME, ICYCLE, IBLOCK
      COMMON /LOAD2/  VF(MM), EZCOOL, IMAT(MM),NODES(MM),
     $                NOMAT, ICASE, ILOAD,ISTRAIN(MM),ISTRAIN2(MM)
      COMMON /STIF / IDAMAGE(10), D(NN), ETA(NN), SPEAK,
     $               DSM, DSCH, DSCL, DM, DTHETA, DDSTAR, DBETA, DDCH
      COMMON /STRES/  S(6,NN), SDEV(6,NN),
     $                SEFF(NN), SE(NN), SEFFOLD(NN)
      COMMON /STRAI/  ETOT(6,NN), DEP(6,NN), EME(6,NN), ETH(NN),
     $                DEFF(NN), EPEFF(NN), DEPOLD(6,NN)
      COMMON /ELASX/ TEO(NN),TE(NN),TNU(NN),TCTE(NN),ECOM,CTECOM
      REAL*8              EP(6,NN)
C
C         Multiple laminates ----------
C     For strain controlled loading after cooldown ez*=eztot
      IF( ILOAD .EQ. 1 ) THEN
        EZSTAR = EZ + EZCOOL
        EZTOT = EZSTAR
        GOTO 10
      ENDIF
      SUM = 0.0
      DO 5 I = 1, NOMAT
        SUM = SUM + TE(I)*VF(I)*EP(3,I)
 5    CONTINUE
```

```
      EZTOT = SZ/ECOM + CTECOM*DT + SUM/ECOM
 10   DO 15 I = 1, NOMAT
        S(1,I) = 0.0
        S(2,I) = 0.0
        S(3,I) = TE(I)*( EZTOT - TCTE(I)*DT - EP(3,I) )
 15   CONTINUE
      RETURN
      END
C
C=====================================================================
C Plastic
C Computes special plastic term in concentric cylinder model
C=====================================================================
C
      FUNCTION PLASTIC( I, EP )
C
      IMPLICIT DOUBLE PRECISION ( A-H,O-Z )
C
      PARAMETER( LDA = 150, MM = 10, MR = 40, ML = 100, MC = 40 )
      PARAMETER( NN = 50)
      COMMON /ELASX/ TEO(NN),TE(NN),TNU(NN),TCTE(NN),ECOM,CTECOM
      COMMON /MATRIX/ AMAT(LDA,LDA), BMAT(LDA), NRA,
     $                IPVT(LDA)
      COMMON /MATRIX2/ AA(NN), BB(NN), CC(NN), DD(NN),
     $                FF(NN), GG(NN), HH(NN), QQ(NN), PP(NN)
      REAL*8              EP(6,NN)
C
      PLASTIC = TE(I)*(
     $  AA(I)*( EP(1,I) + CC(I)*EP(1,I-1) )
     $  - EP(2,I)*( 1 + AA(I) )
     $  + EP(2,I-1)*( 1 - AA(I)*CC(I) )
     $  + TNU(I)*( EP(1,I) + EP(2,I) )
     $  - TNU(I-1)*( EP(1,I-1) + EP(2,I-1) )
     $  )
      RETURN
      END
C
C =====================================================================
C Called from subroutine stress
C Ccm with loading case 5: parallel [90] element
C =====================================================================
      SUBROUTINE STRESS3( EP, ICOUNT )
C
      IMPLICIT DOUBLE PRECISION ( A-H,O-Z )
C
```

```
      PARAMETER( LDA = 150, MM = 10, MR = 40, ML = 100, MC = 40 )
      PARAMETER( NN = 50)
      COMMON /STIF / IDAMAGE(10), D(NN), ETA(NN), SPEAK,
     $               DSM, DSCH, DSCL, DM, DTHETA, DDSTAR, DBETA, DDCH
      COMMON /LOAD2/  VF(MM), EZCOOL, IMAT(MM),NODES(MM),
     $                NOMAT, ICASE, ILOAD,ISTRAIN(MM),ISTRAIN2(MM)
      COMMON /LOADT/  T, SZ, EZ, SR, TAU, DT,
     $                TINCR, SZINCR, EZINCR, SRINCR, DTAU,
     $                TIME, ICYCLE, IBLOCK
      COMMON /ELASX/ TEO(NN),TE(NN),TNU(NN),TCTE(NN),ECOM,CTECOM
      COMMON /CCM1 /  RAD(LDA), IBEG(MM), IEND(MM), NTOT
      COMMON /MATRIX/ AMAT(LDA,LDA), BMAT(LDA), NRA,
     $                IPVT(LDA)
      COMMON /MATRIX2/ AA(NN), BB(NN), CC(NN), DD(NN),
     $                FF(NN), GG(NN), HH(NN), QQ(NN), PP(NN)
      COMMON /STRES/  S(6,NN), SDEV(6,NN),
     $                SEFF(NN), SE(NN), SEFFOLD(NN)
      COMMON /STRAI/  ETOT(6,NN), DEP(6,NN), EME(6,NN), ETH(NN),
     $                DEFF(NN), EPEFF(NN), DEPOLD(6,NN)
      REAL*8              EP(6,NN), XSOL(LDA)
C
      B = 1.0
C     For strain controlled loading after cooldown ez*=eztot
      IF(ILOAD .EQ.1 ) THEN
        EZSTAR = EZ + EZCOOL
        EZTOT = EZSTAR
        GOTO 101
      ENDIF
      NTOT2 = NTOT-2
C     Compute sum( 2/b^2*e/ec* integral(ezp*rdr) )
      SUMTEGRAL = 0.0
      DO 5 I = 2, NTOT2
        TEGRAL =  (RAD(I)-RAD(I-1))*
     $    (EP(3,I)*RAD(I)+EP(3,I-1)*RAD(I-1))
        SUMTEGRAL = SUMTEGRAL + TEGRAL*TE(I)/(B**2*ECOM)
  5   CONTINUE
      TEGRAL = (RAD(NTOT)**2-RAD(NTOT-1)**2)*EP(3,NTOT)
      SUMTEGRAL = SUMTEGRAL + TEGRAL*TE(NTOT)/(B**2*ECOM)
      EZSTAR = SZ/ECOM + CTECOM*DT + SUMTEGRAL
     $  - 2.0*TNU(NTOT2)*SR/ECOM
 101  DO 15  I = 2, NTOT2
        PP(I) = PLASTIC(I,EP) + TE(I)*EZSTAR*( TNU(I) - TNU(I-1) )
 15   CONTINUE
C     Complete b matrix
      DO 60 I = 1, NTOT2-1
```

```
        BMAT(NTOT2-1+I) = QQ(I+1) - PP(I+1)
 60   CONTINUE
C     Add contribution of sr term to the last term in bmat
      ILAST = 2*(NTOT2-1)
      BMAT(ILAST) = QQ(NTOT2) - PP(NTOT2) - DD(NTOT2)*SR
C     Using bmat, and the l-u decomposition of amat determine xsol
      CALL LUBKSB(AMAT,NRA,LDA,IPVT,BMAT,XSOL)
C     Compute stresses from the xsol solution vector
      DO 80 I = 1, NTOT2-1
        S(1,I) = XSOL(I)
        S(2,I+1) = XSOL(NTOT2-1+I)
 80   CONTINUE
C     Boundary conditions
      S(1,NTOT2) = SR
      S(2,1) = S(1,1)
      IF( ILOAD .EQ.1) GOTO 102
C     Compute total axial strain for stress controlled cases
C     From ez*
      SUM = 0.0
      DO 90 I = 2,NOMAT
        J = IBEG(I)
        SUM = SUM + S(1,J)*VF(I-1)*( TNU(J-1) - TNU(J) )
 90   CONTINUE
      EZTOT = EZSTAR - 2.0*SUM/ECOM
C     Compute axial stress from the axial stress-strain equation
 102  DO 95  I = 1, NTOT
        S(3,I) = TE(I)*( EZTOT - EP(3,I) - TCTE(I)*DT )
     $    + TNU(I)*( S(1,I) + S(2,I) )
 95   CONTINUE
      RETURN
      END
C
C =====================================================================
C Called from subroutine stress
C
C     Concentric cylinder model
C
C =====================================================================
      SUBROUTINE STRESS1( EP, ICOUNT )
C
      IMPLICIT DOUBLE PRECISION ( A-H,O-Z )
C
      PARAMETER( LDA = 150, MM = 10, MR = 40, ML = 100, MC = 40 )
      PARAMETER( NN = 50)
      COMMON /LOAD2/  VF(MM), EZCOOL, IMAT(MM),NODES(MM),
```

```
     $                NOMAT, ICASE, ILOAD,ISTRAIN(MM),ISTRAIN2(MM)
      COMMON /LOADT/  T, SZ, EZ, SR, TAU, DT,
     $                TINCR, SZINCR, EZINCR, SRINCR, DTAU,
     $                TIME, ICYCLE, IBLOCK
      COMMON /ELASX/ TEO(NN),TE(NN),TNU(NN),TCTE(NN),ECOM,CTECOM
      COMMON /CCM1 /  RAD(LDA), IBEG(MM), IEND(MM), NTOT
      COMMON /MATRIX/ AMAT(LDA,LDA), BMAT(LDA), NRA,
     $                IPVT(LDA)
      COMMON /MATRIX2/ AA(NN), BB(NN), CC(NN), DD(NN),
     $                FF(NN), GG(NN), HH(NN), QQ(NN), PP(NN)
      COMMON /STRES/  S(6,NN), SDEV(6,NN),
     $                SEFF(NN), SE(NN), SEFFOLD(NN)
      COMMON /STRAI/  ETOT(6,NN), DEP(6,NN), EME(6,NN), ETH(NN),
     $                DEFF(NN), EPEFF(NN), DEPOLD(6,NN)
      REAL*8              EP(6,NN), XSOL(LDA)
C
      B = 1.0
C     For strain controlled loading after cooldown ez*=eztot
      IF( ILOAD .EQ. 1 ) THEN
        EZSTAR = EZ + EZCOOL
        EZTOT = EZSTAR
        GOTO 101
      ENDIF
C     Stress control
      SUMTEGRAL = 0.0
      DO 5 I = 2, NTOT
        TEGRAL =  (RAD(I)-RAD(I-1))*
     $    (EP(3,I)*RAD(I) + EP(3,I-1)*RAD(I-1))
        SUMTEGRAL = SUMTEGRAL + TEGRAL*TE(I)/(B**2*ECOM)
  5   CONTINUE
      EZSTAR = SZ/ECOM + CTECOM*DT + SUMTEGRAL
     $  - 2.0*TNU(NTOT)*SR/ECOM
C     Strain control
 101  DO 15 I = 2, NTOT
        PP(I) = PLASTIC(I,EP) + TE(I)*EZSTAR*( TNU(I) - TNU(I-1) )
  15  CONTINUE
C     Complete b matrix
      DO 60 I = 1, NTOT-1
        BMAT(NTOT-1+I) = QQ(I+1) - PP(I+1)
 60   CONTINUE
C     Add contribution of sr term to the last term in bmat
      ILAST = 2*(NTOT-1)
      BMAT(ILAST) = QQ(NTOT) - PP(NTOT) - DD(NTOT)*SR
C     Using bmat, and the l-u decomposition of amat determine xsol
      CALL LUBKSB(AMAT,NRA,LDA,IPVT,BMAT,XSOL)
```

```
C     Compute stresses from the xsol solution vector
      DO 80 I = 1, NTOT-1
        S(1,I) = XSOL(I)
        S(2,I+1) = XSOL(NTOT-1+I)
 80   CONTINUE
C     Boundary conditions
      S(1,NTOT) = SR
      S(2,1) = S(1,1)
      IF( ILOAD .EQ. 1 ) GOTO 102
C     Compute total axial strain for stress controlled cases
C     From ez*
      SUM = 0.0
      DO 90 I = 2,NOMAT
        J = IBEG(I)
        SUM = SUM + S(1,J)*VF(I-1)*( TNU(J-1) - TNU(J) )
 90   CONTINUE
      EZTOT = EZSTAR - 2.0*SUM/ECOM
C     Compute axial stress from the axial stress-strain equation
 102  DO 95 I = 1, NTOT
        S(3,I) = TE(I)*( EZTOT - EP(3,I) - TCTE(I)*DT )
     $    + TNU(I)*( S(1,I) + S(2,I) )
  95  CONTINUE
      RETURN
      END
C
C =====================================================================
C Called from propnodes
C =====================================================================
      SUBROUTINE ELAS( I, K )
C
      IMPLICIT DOUBLE PRECISION ( A-H,O-Z )
C
      PARAMETER( LDA = 150, MM = 10, MR = 40, ML = 100, MC = 40 )
      PARAMETER( NN = 50)
      COMMON /ELASX/ TEO(NN),TE(NN),TNU(NN),TCTE(NN),ECOM,CTECOM
      COMMON  /PROP /  P(MM, MC)
      COMMON /STIF / IDAMAGE(10), D(NN), ETA(NN), SPEAK,
     $               DSM, DSCH, DSCL, DM, DTHETA, DDSTAR, DBETA, DDCH
C
      TNU(K) = P(I,2)
      TCTE(K) = P(I,3)*1.0E-6
      TE(K) = P(I,1)*1.0E3
C********** for damage in 90  *****************
      TEO(K) = TE(K)
      RETURN
```

```
      END
C =====================================================================
      SUBROUTINE MAT2( I, K )
C
      IMPLICIT DOUBLE PRECISION ( A-H,O-Z )
C
      PARAMETER( LDA = 150, MM = 10, MR = 40, ML = 100, MC = 40 )
      PARAMETER( NN = 50)
      COMMON  /MAT2A/  TSY(NN), TEP(NN)
      COMMON  /PROP/  P(MM, MC)
C
      TSY(K) = P(I,4)
      TEP(K) = P(I,5)*1.0E3
      RETURN
      END
C =====================================================================
      SUBROUTINE MAT5( I, K, ICOUNT )
C
      IMPLICIT DOUBLE PRECISION ( A-H,O-Z )
C
      PARAMETER( LDA = 150, MM = 10, MR = 40, ML = 100, MC = 40 )
      PARAMETER( NN = 50)
      COMMON  /MAT5A/  TN(NN), TZ0(NN), TF1(NN), TF3(NN),
     $                 TBSMAX(NN),  TD0(NN)
      COMMON /MAT5B/  F3OLD(NN), BS(6,NN), SDEVOLD(6,NN)
      COMMON  /PROP/  P(MM, MC)
      COMMON /MAT7A / TA1A(NN),TA1B(NN),TA1C(NN),
     $                TM1A(NN),TM1B(NN),TM1C(NN),
     $                TA2(NN)
C
      TN(K)      = P(I,5)
      TZ0(K)     = P(I,6)
      TF1(K)     = P(I,7)
      TF3(K)     = P(I,8)
      IF(ICOUNT .EQ. 0)  F3OLD(K) = TF3(K)
      TBSMAX(K)  = P(I,9)
      TD0(K)     = P(I,10)
      RETURN
      END
C =====================================================================
      SUBROUTINE MAT6( I, K, ICOUNT )
C
      IMPLICIT DOUBLE PRECISION ( A-H,O-Z )
C
      PARAMETER( LDA = 150, MM = 10, MR = 40, ML = 100, MC = 40 )
```

```
      PARAMETER( NN = 50)
      COMMON /MAT6A /  TND(NN), TZ0D(NN), TZ3(NN), TM2(NN),
     $                 TA1(NN), TM1(NN), TZ1(NN), TR1(NN),
     $                 TR2(NN), TD0D(NN), TZ2(NN),
     $                 DTZ1(NN), DTZ2(NN), DTZ3(NN)
      COMMON /MAT6B/  BETA(6,NN),ZD(NN),ZI(NN),ZTOT(NN)
      COMMON  /PROP/  P(MM, MC)
      COMMON /STIF / IDAMAGE(10), D(NN), ETA(NN), SPEAK,
     $               DSM, DSCH, DSCL, DM, DTHETA, DDSTAR, DBETA, DDCH
C
      TND(K) = P(I,5)
      IF( ICOUNT .EQ. 0 ) THEN
        TZ0DOLD   = P(I,6)
        ZI(K)     = P(I,6)
        ZTOT(K)   = P(I,6)
      ENDIF
      TZ0DOLD = TZ0D(K)
      TZ0D(K) = P(I,6)
      TZ2(K)  = TZ0D(K)
      DTZ2(K) = TZ0D(K) - TZ0DOLD
      TZ3OLD = TZ3(K)
      TZ3(K) = P(I,7)
      IF( ICOUNT .EQ. 0 )TZ3OLD = P(I,7)
      DTZ3(K) = TZ3(K) - TZ3OLD
      TM2(K) = P(I,8)
      TA1(K) = P(I,9)
      TM1(K) = P(I,10)
      TZ1OLD = TZ1(K)
      TZ1(K) = P(I,11)
      IF( ICOUNT .EQ. 0 )TZ1OLD = TZ1(K)
      DTZ1(K) = TZ1(K) - TZ1OLD
      TR1(K) = P(I,12)
      TR2(K) = TR1(K)
      TD0D(K) = P(I,13)
C ****** damage in 90 ******************************************
      IF( IDAMAGE(I) .EQ. 1 )THEN
        DSM  = P(I,14)
        DSCH = P(I,15)
        DSCL = P(I,16)
        DM   = P(I,17)
        DTHETA = P(I,18)
        DDSTAR = P(I,19)
        DBETA  = P(I,20)
        DDCH   = P(I,21)
      ENDIF
```

```
      RETURN
      END
C =====================================================================
      SUBROUTINE MAT7( I, K, ICOUNT )
C
      IMPLICIT DOUBLE PRECISION ( A-H,O-Z )
C
      PARAMETER( LDA = 150, MM = 10, MR = 40, ML = 100, MC = 40 )
      PARAMETER( NN = 50)
      COMMON /MAT6A /  TND(NN), TZ0D(NN), TZ3(NN), TM2(NN),
     $                 TA1(NN), TM1(NN), TZ1(NN), TR1(NN),
     $                 TR2(NN), TD0D(NN), TZ2(NN),
     $                 DTZ1(NN), DTZ2(NN), DTZ3(NN)
      COMMON /MAT7A / TA1A(NN),TA1B(NN),TA1C(NN),
     $                 TM1A(NN),TM1B(NN),TM1C(NN),
     $                 TA2(NN)
      COMMON /MAT6B/  BETA(6,NN),ZD(NN),ZI(NN),ZTOT(NN)
      COMMON  /PROP/  P(MM, MC)
      COMMON /STIF / IDAMAGE(10), D(NN), ETA(NN), SPEAK,
     $               DSM, DSCH, DSCL, DM, DTHETA, DDSTAR, DBETA, DDCH
C
      TND(K)  = P(I,5)
      IF( ICOUNT .EQ. 0 ) THEN
        TZ0DOLD   = P(I,6)
        ZI(K)     = P(I,6)
        ZTOT(K)   = P(I,6)
      ENDIF
      TZ0DOLD = TZ0D(K)
      TZ0D(K) = P(I,6)
      TZ2(K)  = TZ0D(K)
      DTZ2(K) = TZ0D(K) - TZ0DOLD
      TZ3OLD = TZ3(K)
      TZ3(K) = P(I,7)
      IF( ICOUNT .EQ. 0 )TZ3OLD = P(I,7)
      DTZ3(K) = TZ3(K) - TZ3OLD
      TM1A(K) = P(I,8)
      TM1B(K) = P(I,9)
      TM1C(K) = P(I,10)
      TM2(K)  = P(I,11)
      TA1A(K) = P(I,12)
      TA1B(K) = P(I,13)
      TA1C(K) = P(I,14)
      TA2(K)  = P(I,15)
      TZ1OLD = TZ1(K)
      TZ1(K) = P(I,16)
```

```
      IF( ICOUNT .EQ. 0 )TZ1OLD = TZ1(K)
      DTZ1(K) = TZ1(K) - TZ1OLD
      TR1(K) = P(I,17)
      TR2(K) = TR1(K)
      TD0D(K) = P(I,19)
      RETURN
      END
C =====================================================================
C Geometry: called from main program
C Define geometric properties
C =====================================================================
      SUBROUTINE GEOMETRY
C
      IMPLICIT DOUBLE PRECISION ( A-H,O-Z )
C
      PARAMETER( LDA = 150, MM = 10, MR = 40, ML = 100, MC = 40 )
      PARAMETER( NN = 50)
      COMMON /CCM1 /  RAD(LDA), IBEG(MM), IEND(MM), NTOT
      COMMON /LOAD2/  VF(MM), EZCOOL, IMAT(MM),NODES(MM),
     $                NOMAT, ICASE, ILOAD,ISTRAIN(MM),ISTRAIN2(MM)
C
      REAL*8        A(10)
      IF (ICASE .EQ. 2)  THEN
        DO 3 I = 1, NOMAT
          IBEG(I) = I
          IEND(I) = I
 3      CONTINUE
        NTOT = NOMAT
        RETURN
      ENDIF
      NTOT   = 1
      B = 1
C     Compute total number of nodes
      DO 5 I = 1, NOMAT
        IBEG(I)  =   NTOT
        IEND(I)  =   IBEG(I) + NODES(I) - 1
        NTOT     =   IEND(I) + 1
 5    CONTINUE
      NTOT     =   IEND(NOMAT)
C     Continue with concentric cylinder model
C     Compute radii limits for each material block
      VFSUM = 0
      DO 10 I = 1, NOMAT
        VFSUM = VFSUM + VF(I)
        A(I+1) = B*SQRT(VFSUM)
```

```
 10   CONTINUE
      A(1)      = 0
      RAD(1)    = 1.E-22
C     Compute location of nodes
      POWER = 1
      DO 200 I = 1, NOMAT
        RSTEP = (A(I+1) - A(I))/(NODES(I)-1)
        KSUM  = 0
        DO 195 J = IBEG(I), IEND(I)
          RAD(J) = A(I) + FLOAT(KSUM) *  RSTEP
          IF(J .EQ. IBEG(I)) THEN
            RAD(J) = RAD(J) + 1.E-12
          ENDIF
          KSUM = KSUM + 1
 195    CONTINUE
 200  CONTINUE
      RETURN
      END
C =====================================================================
C Called from newcte
C =====================================================================
      SUBROUTINE INTERPOL( J, XIN, TE, T, NLAST, OUTMAT, JFAC )
C
      IMPLICIT DOUBLE PRECISION ( A-H,O-Z )
C
      PARAMETER( LDA = 150, MM = 10, MR = 40, ML = 100, MC = 40 )
      PARAMETER( NN = 50)
      REAL*8   XIN(MR), TE(MR), OUTMAT
C
      IF( NLAST .EQ. 1 )THEN
        OUTMAT = XIN(1)
        RETURN
      ENDIF
      IF( J.EQ.NLAST )THEN
        J1 = J - 1 - JFAC
        J2 = J - JFAC
      ELSEIF( J.EQ.1 )THEN
        J1 = J + JFAC
        J2 = J + 1 + JFAC
      ELSE
        J1 = J - 1
        J2 = J + JFAC
      END IF
      T1 = TE(J1)
      T2 = TE(J2)
```

```
      VAR1 = XIN(J1)
      VAR2 = XIN(J2)
      OUTMAT = (T-T1)/(T2-T1)*(VAR2-VAR1) + VAR1
      RETURN
      END
C
C =====================================================================
C  Inter
C  Determines temperature dependent properties at temperature t
C =====================================================================
C
      SUBROUTINE INTER( I, J, K, L, T )
C
      IMPLICIT DOUBLE PRECISION ( A-H,O-Z )
C
C     I = material, j = row, k = column, l = set numbers
      PARAMETER( LDA = 150, MM = 10, MR = 40, ML = 100, MC = 40 )
      PARAMETER( NN = 50)
      COMMON  /READM/  NROW(MM,7), NCOL(MM,7), TP(MM,MR,MC),
     $                 AT(MM,MR,7), TREF(MM), NSET(MM)
      COMMON  /PROP/   P(MM,MC)
C
      NLAST = NROW(I,L)
      IF( J.EQ.NLAST )THEN
        J1 = J - 1
        J2 = J
      ELSEIF( J.EQ.1 )THEN
        J1 = J
        J2 = J + 1
      ELSE
        J1 = J - 1
        J2 = J
      END IF
      P(I,K) = FUNCINTER( AT(I,J1,L), AT(I,J2,L), TP(I,J1,K),
     $  TP(I,J2,K), T )
      RETURN
      END
C
C =====================================================================
C Funcinter
C Computes linear interpolation
C =====================================================================
C
      FUNCTION FUNCINTER( T1, T2, VAR1, VAR2, T )
C
```

```
      IMPLICIT DOUBLE PRECISION ( A-H,O-Z )
C
      IF( T1 .EQ. T2 )THEN
        FUNCINTER = ( VAR1 + VAR2 )/2.0
        RETURN
      ENDIF
      FUNCINTER = (T-T1)/(T2-T1)*(VAR2-VAR1) + VAR1
      RETURN
      END
C
C =====================================================================
C Inelastic
C Compute inelastic strain increments and iterate to converge to the
C Right combination of stresses and strains
C =====================================================================
C
      SUBROUTINE INELASTIC(ITYPE, EP )
C
      IMPLICIT DOUBLE PRECISION ( A-H,O-Z )
C
      PARAMETER( LDA = 150, MM = 10, MR = 40, ML = 100, MC = 40 )
      PARAMETER( NN = 50)
      COMMON /LOADT/  T, SZ, EZ, SR, TAU, DT,
     $                TINCR, SZINCR, EZINCR, SRINCR, DTAU,
     $                TIME, ICYCLE, IBLOCK
      COMMON /LOADO/  INTOUT(ML),IOUT(ML,20),
     $                IPRINTSTEP(ML),ISTEPOUT(ML)
      COMMON /LOAD2/  VF(MM), EZCOOL, IMAT(MM),NODES(MM),
     $                NOMAT, ICASE, ILOAD,ISTRAIN(MM),ISTRAIN2(MM)
      COMMON /ELASX/ TEO(NN),TE(NN),TNU(NN),TCTE(NN),ECOM,CTECOM
      COMMON /MAT2A /  TSY(NN), TEP(NN)
      COMMON /MAT5A /  TN(NN), TZ0(NN), TF1(NN), TF3(NN),
     $                TBSMAX(NN),  TD0(NN)
      COMMON /MAT6A /  TND(NN), TZ0D(NN), TZ3(NN), TM2(NN),
     $                TA1(NN), TM1(NN), TZ1(NN), TR1(NN),
     $                TR2(NN), TD0D(NN), TZ2(NN),
     $                DTZ1(NN), DTZ2(NN), DTZ3(NN)
      COMMON /MAT7A / TA1A(NN),TA1B(NN),TA1C(NN),
     $                TM1A(NN),TM1B(NN),TM1C(NN),
     $                TA2(NN)
      COMMON /CCM1 /  RAD(LDA), IBEG(MM), IEND(MM), NTOT
      COMMON /MATRIX/ AMAT(LDA,LDA), BMAT(LDA), NRA,
     $                IPVT(LDA)
      COMMON /MATRIX2/ AA(NN), BB(NN), CC(NN), DD(NN),
     $                FF(NN), GG(NN), HH(NN), QQ(NN), PP(NN)
```

```
      COMMON /STIF / IDAMAGE(10), D(NN), ETA(NN), SPEAK,
     $               DSM, DSCH, DSCL, DM, DTHETA, DDSTAR, DBETA, DDCH
      COMMON /STRES/  S(6,NN),  SDEV(6,NN),
     $                SEFF(NN), SE(NN), SEFFOLD(NN)
      COMMON /STRAI/  ETOT(6,NN), DEP(6,NN), EME(6,NN), ETH(NN),
     $                DEFF(NN), EPEFF(NN), DEPOLD(6,NN)
      COMMON /MAT5B/  F3OLD(NN), BS(6,NN), SDEVOLD(6,NN)
      COMMON /MAT6B/  BETA(6,NN),ZD(NN),ZI(NN),ZTOT(NN)
      COMMON /CONTROL/ TOLER1, TOLER2, RELAX, FAST, ICOUNT,
     $                 ISUBTOT, IZMAX, MAXITER
C
      REAL*8           EP(6,NN), EP2(6,NN), EMTS(6), EPEST
      REAL*8           SEFFEST(NN),  DEFFOLD(NN), V(3), U(3)
      REAL*8 BSOLD(6,NN),BSEST(6,NN),ZTEST(NN),BOLD(6,NN),ZIOLD(NN)
      INTEGER          ITYPE(MM), IYLDFLG(NN), K, IDUMMY(NN)
C
C     If all the materials are elastic, then return to main
      IPLAS = 0
      DO 10 I = 1, NOMAT
        GOTO(10,20,20,10,30,30)  ITYPE(I)
 20     DO 21 J = IBEG(I), IEND(I)
          SE(J) = YSURFACE( EPEFF(J), J )
          SEFF(J) = CSEFF( J )
          IF( SEFF(J) .GT. SE(J) ) IPLAS = 1
 21     CONTINUE
        GOTO 10
 30     IPLAS = 1
 10   CONTINUE
      IF(IPLAS .EQ. 0) GOTO 777
C     Plastic step starts here
C     Set state variables for iterations
      DO 5  N = 1, NTOT
        ZTEST(N) = ZTOT(N)
        ZIOLD(N) = ZI(N)
        SEFFEST(N) = SEFF(N)
        DO 5  K = 1, 3
          BSOLD(K,N) = BS(K,N)
          BSEST(K,N) = BS(K,N)
          BOLD(K,N)  = BETA(K,N)
 5    CONTINUE
      IC      = 1
 800  CONTINUE
      DO 40 I = 1, NOMAT
        GOTO(40,45,50,40,60,70,70)  ITYPE(I)
C       Plasticity model
```

```
 45     DO 46 J = IBEG(I), IEND(I)
          DEFF(J)  = 0.0
          DO 46 K = 1,3
            DEP(K,J) = 0.0
 46     CONTINUE
        GOTO 40
C       Compute for incremental strain model
 50     DO 51 J = IBEG(I), IEND(I)
          DO 51 K = 1, 3
            DEP(K,J) = DEPOLD(K,J)
 51     CONTINUE
        GOTO 40
C       Compute for backstress model
 60     DO 61 J = IBEG(I), IEND(I)
          SEFF(J)    = CK2( J )
          DEFFOLD(J) = CDEFF5( J )    !=CALCDEFF(DEP,J)
 61     CONTINUE
        GOTO 40
C       Directional bodner model
 70     DO 71 J = IBEG(I), IEND(I)
          SEFF(J)    = SEFFEST( J )
          DEFFOLD(J) = CDEFF6( J, ZTEST )
 71     CONTINUE
 40   CONTINUE
C     Iterations for inelastic strains start here ----------
      DO 700 ITER = 1, MAXITER
C       Compute new estimates for the plastic strain increments
        DO 100 I = 1, NOMAT
          GOTO(100,120,130,100,150,160,160)  ITYPE(I)
C         Elastic-plastic
 120      DO 121 J = IBEG(I), IEND(I)
            SEFFOLD(J) = SEFF( J )
            SEFF(J) = CSEFF( J )
            SE(J) = YSURFACE( EPEFF(J), J )
            F = SEFF(J) - SE(J)
            IF( F .GT. 0 )GOTO 122
            IYLDFLG(J) = 0
            DEFF(J) = 0.0
            GOTO 121
 122        IYLDFLG(J) = 2
C           Calculate modified total strains
            DO 124 K = 1, 3
              EMTS(K) = ETOT(K,J) - EP(K,J)   ! EP IS W/O DEP
 124        CONTINUE
C           Calculate equivalent (effective) modified total strain
```

```
            SS1 = EMTS(1) - EMTS(2)
            SS2 = EMTS(3) - EMTS(2)
            SS3 = EMTS(1) - EMTS(3)
            EET = SQRT( SS1*SS1 + SS2*SS2 + SS3*SS3 )*SQRT(2.)/3.
C           Relationship between dep or psi and eff mts
            XM = TEP(J) / TE(J)
            DSDE = XM*TE(J)/( 1. - XM )
            DENOMDEP = 1. + 2./3.*( 1 + TNU(J) )/TE(J)*DSDE
            DEFF(J) = EET - 2./3.*(1+TNU(J))/TE(J)*SE(J)
            DEFF(J) = DEFF(J)/DENOMDEP
C           Calculate new psis using modified p-r equations
            COEFF = DEFF(J)/3./EET
            DEP(1,J) = COEFF*( 2*EMTS(1)-EMTS(2)-EMTS(3) )
            DEP(2,J) = COEFF*( 2*EMTS(2)-EMTS(1)-EMTS(3) )
            DEP(3,J) = COEFF*( 2*EMTS(3)-EMTS(1)-EMTS(2) )
 121      CONTINUE
          GOTO 100
C         Bilinear elastic-plastic-damage with 2nd el-pl algorithm
 130      DO 131 J = IBEG(I), IEND(I)
            SEFFOLD(J) = SEFF(J)
            SEFF(J) = CSEFF( J )
            SE(J) = YSURFACE( EPEFF(J), J )
C           Check stress state for yielding at node j
            F = SEFF(J) - SE(J)
            IF( F .GT. 0 )GOTO 134
C           If f<0 during iterations, still iterate for conv.
            IF( IYLDFLG(J) .GT. 1 ) GOTO 134
            IYLDFLG(J) = 0
            GOTO 131
 134        IYLDFLG(J) = 2
C           For algorithm 2 start iterations with nonzero ep
            IDUMMY(J) = IDUMMY(J) + 1
            IF( IDUMMY(J) .EQ. 1 ) THEN
              DEFFX = ( SEFF(J) - SE(J) )/TE(J)
              DEP(1,J) = -DEFFX/2.0
              DEP(2,J) = -DEFFX/2.0
              DEP(3,J) = DEFFX
              PRINT *, '1ST GUESS AT DEP:', J, DEP(3,J)
            ENDIF
C           Compute equivalent plastic strain
            TERM12 = ( DEP(1,J) - DEP(2,J) )**2
            TERM13 = ( DEP(1,J) - DEP(3,J) )**2
            TERM23 = ( DEP(3,J) - DEP(2,J) )**2
            DEFF(J) = SQRT(2.*(TERM12+TERM13+TERM23))/3.0
C           Compute the yield surface, se from epeff
```

```
            EPEST = EPEFF(J) + DEFF(J)
            SE(J) = YSURFACE( EPEST, J )
 131      CONTINUE
          GOTO 100
C         Bodner-partom with backstress
 150      DO 151 J = IBEG(I), IEND(I)
            C    = SEFF( J )
            IF( SEFF(J) .LT. 1.E-12 ) C = 1.0E-12
            DO 151 K = 1, 3
              DEP(K,J) = DEFFOLD(J)*(SDEV(K,J)-BSEST(K,J))/C
 151      CONTINUE
          GOTO 100
C         Bodner-partom with directional hardening
 160      DO 161 J = IBEG(I), IEND(I)
            C = SEFF(J)
            IF( SEFF(J) .LT. 1.E-12 ) C = 1.0E-12
            DO 161 K = 1, 3
              DEP(K,J)  = SQRT(3.)* DEFFOLD(J)*SDEV(K,J)/C
 161      CONTINUE
 100    CONTINUE
        DO 105 J = 1, NTOT
          SEFFOLD(J) = SEFF(J)
          DO 105 K = 1, 3
            EP2(K,J) = EP(K,J) + DEP(K,J)
 105    CONTINUE
C       Compute stresses given the plastic strain estimates
        CALL STRESS( EP2, ICOUNT )
C       Evolution equations for the internal state variables
        ERROR1 = 0.0
        DO 95  I = 1, NOMAT
          ID = IBEG(I)
          DIFF = ABS (SEFF(ID)-SEFFOLD(ID))
          IF(SEFF(ID) .GT. 1.E-12) DIFF = DIFF/SEFF(ID)
          ERROR1 = ERROR1 + DIFF
 95     CONTINUE
        DO 200 I = 1, NOMAT
          GOTO(200,200,230,200,250,200,270) ITYPE(I)
C         B-p with elastic-plastic algorithm #2
 230      DO 231 J = IBEG(I), IEND(I)
            FACTOR = DEFF(J)/2./SE(J)
            DEP(1,J) = FACTOR*( 2*S(1,J)-S(2,J)-S(3,J) )
            DEP(2,J) = FACTOR*( 2*S(2,J)-S(1,J)-S(3,J) )
            DEP(3,J) = FACTOR*( 2*S(3,J)-S(1,J)-S(2,J) )
            DEP(3,J) = - DEP(1,J) - DEP(2,J)
 231      CONTINUE
```

```
 250      DO 251 J = IBEG(I), IEND(I)
            SEFF(J) = CK2( J )
 251      CONTINUE
          GOTO 200
 270      DO 271 J = IBEG(I), IEND(I)
            SEFF(J) = SEFFOLD(J)*(1.0-RELAX)+SEFF(J)*RELAX
            DEFFOLD(J) = CDEFF6( J, ZTEST )
 271      CONTINUE
 200    CONTINUE
        IF( ITER .EQ. MAXITER )THEN
          WRITE(6,*)
          WRITE(6,*) ' STRESS DISTRIBUTION REFUSES TO CONVERGE '
          WRITE(6,*) ' ON CYCLE  ', ICOUNT
          WRITE(6,*)
          STOP
        ENDIF
        IF(ITER .GT. 2 .AND.  ERROR1 .LT. TOLER1 ) THEN
          GOTO 701
        ENDIF
 700  CONTINUE     ! ITERATION LOOP
 701  CONTINUE     ! END OF ITERATIONS
        FAST1 = FLOAT(ITER-3) / FLOAT(MAXITER)
C     Update state variables
      ZERR    = 0
      BSERR   = 0
      BSMEAN  = 0
      SERR    = 0
      SMEAN   = 0
      DO 80  I = 1, NOMAT
        IF( ITYPE(I) .EQ. 5 ) THEN
          DO 81 J = IBEG(I), IEND(I)
            DF3      = TF3(J) - F3OLD(J)
            F3OLD(J) = TF3(J)
            DEFF(J)  = CDEFF(DEP, J )
            SERR = SERR + ABS(SEFFEST(J) - SEFF(J))
            SEFFEST(J) = SEFFEST(J)*(1.0-RELAX)+SEFF(J)*RELAX
            SMEAN  = SMEAN + ABS(SEFF(J))
  81      CONTINUE
          DO 82 J = IBEG(I), IEND(I)
            DO 82 K = 1, 3
              DSDEV    = SDEV(K,J) - SDEVOLD(K,J)
              DBS = TF3(J)  *  DSDEV
     $          + DF3     *  SDEV(K,J)
     $          + TF1(J)  *  DEP(K,J)
     $          - 2.0* TF1(J)*BS(K,J)*DEFFOLD(J)/(3.*TBSMAX(J))
```

```
              BS(K,J) = BSOLD(K,J) + DBS
              BSERR = BSERR + ABS(BS(K,J)-BSEST(K,J))
              BSEST(K,J) = BS(K,J)
              BSMEAN = BSMEAN + ABS(BS(K,J))
              SDEVOLD(K,J) = SDEV(K,J)
 82         CONTINUE
            IF(ABS(BSMEAN) .GT. 1.E-6) BSERR = BSERR / BSMEAN
          ENDIF
C         B-p with directional hardening
          IF( ITYPE(I) .EQ. 6 ) THEN
            DO 84 J = IBEG(I), IEND(I)
C ***************  damage for 90 *********************************
              IF(IDAMAGE(I) .EQ. 1 )THEN
                IF( D(J) .LT. DDCH ) THEN
                  DSCHNEW = DSCH*( 1. - D(J)/DDCH )
                ELSE
                  DSCHNEW = 0.0
                ENDIF
C               Warning - - - -  - -
C               Eta(j) = 1.
                ETA(J) = 1./(1.+EXP(-DBETA*S(3,J)))
                IF( S(3,J) - DSM - DSCHNEW .GE. SPEAK ) THEN
                  TERM = ((S(3,J)-DSM-DSCHNEW)/DTHETA)**DM
                  D(J) = DDSTAR*(1.0-EXP(-TERM))
                ENDIF
              ENDIF
C ************************************************************
C             Compute work rate, ssum, bsum=sqrt(bij*bij)
              DWORK = 0.0
              SSUM  = 0.0
              BSUM  = 0.0
              DO 262 K = 1, 3
                DWORK = DWORK + S(K,J)*DEP(K,J)/(1-ETA(J)*D(J))
                SSUM  = SSUM  + S(K,J)*S(K,J)
                BSUM  = BSUM  + BETA(K,J)**2
 262          CONTINUE
              SSUM = SQRT(SSUM)
              BSUM = SQRT(BSUM)
C             Compute v(i) and u(i) vectors
              DO 263  K = 1, 3
                V(K) = BETA(K,J)
                IF(BSUM.GT.1.E-15) V(K)=BETA(K,J)/BSUM
                U(K) = S(K,J)
                IF(SSUM.GT.1.E-15) U(K)=S(K,J)/SSUM
 263          CONTINUE
```

```
            ZD(J) = 0.0
            DO 264 K = 1, 3
              TERMH = (TZ3(J)*U(K)-BETA(K,J) )*DWORK
              TERMR = TZ1(J)*V(K)*((BSUM/TZ1(J))**TR2(J))
              TERMT = 0.0
              IF(TZ3(J) .GT. 0)  TERMT = BETA(K,J)*DTZ3(J)/TZ3(J)
              BETA(K,J)    = BOLD(K,J)
     $          + TERMH*TM2(J)
     $          - TERMR*TA1(J)*DTAU
     $          + TERMT
C             Compute directional hardening zd = bijuij
              ZD(J) = ZD(J) + BETA(K,J)*U(K)
 264        CONTINUE
C           Compute isotropic hardening
            TERMH = TM1(J)*(TZ1(J)-ZI(J))*DWORK
            TERMR = TA1(J)*TZ1(J)*((ZI(J)-TZ2(J))/TZ1(J))**TR1(J)
            COEFF1 = (ZI(J)-TZ2(J))/(TZ1(J)-TZ2(J))
            COEFF2 =  (TZ1(J)-ZI(J))/(TZ1(J)-TZ2(J))
C           For this case
C            Coeff1 = 1.0
C            Coeff2 = 1.0
            TERMT = COEFF2*DTZ2(J)
            DZI = TERMH - TERMR*DTAU + TERMT
            ZI(J) = ZIOLD(J) + DZI
C           Compute total drag stress
            ZTOT(J) = ZD(J) + ZI(J)
            ZERR = ZERR + ABS(ZTOT(J) - ZTEST(J))/ZTOT(J)
            ZTEST(J) = ZTEST(J)*(1.-RELAX)+ZTOT(J)*RELAX
c            ZTEST(J) = ZTOT(J)
            SERR = SERR + ABS(SEFFEST(J) - SEFF(J))
            SEFFEST(J) = SEFFEST(J)*(1.0-RELAX)+SEFF(J)*RELAX
            SMEAN  = SMEAN + ABS(SEFF(J))
C ************** damage in 90 *********************
            IF( IDAMAGE(I) .EQ. 1 ) THEN
              ZTOT(J) = ZTOT(J)*(1-ETA(J)*D(J))
              IF( S(3,J) - DSM - DSCHNEW .GT. SPEAK ) THEN
                SPEAK = S(3,J) - DSM - DSCHNEW
              ENDIF
            ENDIF
C ***********************************************
            DEFF(J) = CDEFF6(J,ZTOT)
 84       CONTINUE
        ENDIF
C       B-p star with directional hardening
C       Modified via. neu and bodner september, 1995
```

```
        IF( ITYPE(I) .EQ. 7 ) THEN
          DO 85 J = IBEG(I), IEND(I)
C           Compute work rate, ssum, bsum=sqrt(bij*bij)
            DWORK = 0.0
            SSUM  = 0.0
            BSUM  = 0.0
            DO 272 K = 1, 3
              DWORK = DWORK + S(K,J)*DEP(K,J)
              SSUM  = SSUM  + S(K,J)*S(K,J)
              BSUM  = BSUM  + BETA(K,J)**2
 272        CONTINUE
            SSUM = SQRT(SSUM)
            BSUM = SQRT(BSUM)
C           Compute v(i) and u(i) vectors
            DO 273  K = 1, 3
              V(K) = BETA(K,J)
              IF(BSUM.GT.1.E-15) V(K)=BETA(K,J)/BSUM
              U(K) = S(K,J)
              IF(SSUM.GT.1.E-15) U(K)=S(K,J)/SSUM
 273        CONTINUE
            ZD(J) = 0.0
            DO 274 K = 1, 3
              TERMH = (TZ3(J)*U(K)-BETA(K,J) )*DWORK
              TERMR = TZ1(J)*V(K)*((BSUM/TZ1(J))**TR2(J))
              TERMT = 0.
              IF(TZ3(J) .GT. 0 ) TERMT = BETA(K,J)*DTZ3(J)/TZ3(J)
              BETA(K,J)    = BOLD(K,J)
     $          + TERMH*TM2(J)
     $          - TERMR*TA2(J)*DTAU
     $          + TERMT
C             Compute directional hardening zd = bijuij
              ZD(J) = ZD(J) + BETA(K,J)*U(K)
 274        CONTINUE
C           Compute isotropic hardening
            XM1   = TM1B(J) + (TM1A(J)-TM1B(J))
     $        * DEXP(-1.*TM1C(J)*(ZI(J)-TZ0D(J)))
            XA1   = TA1B(J) + (TA1A(J)-TA1B(J))
     $        * DEXP(-1.*TA1C(J)*(ZI(J)-TZ2(J)))
            TERMH = XM1*(TZ1(J)-ZI(J))*DWORK
            TERMR = XA1*TZ1(J)*(ABS((ZI(J)-TZ2(J))/TZ1(J)))**TR1(J)
            COEFF1 = (ZI(J)-TZ2(J))/(TZ1(J)-TZ2(J))
            COEFF2 = (TZ1(J)-ZI(J))/(TZ1(J)-TZ2(J))
            TERMT = COEFF2*DTZ2(J)
            DZI = TERMH - TERMR*DTAU + TERMT
            ZI(J) = ZIOLD(J) + DZI
```

```
            IF(ZI(J) .LT. TZ2(J)) ZI(J) = TZ2(J)
C           Compute total drag stress
            ZTOT(J) = ZD(J) + ZI(J)
            ZERR = ZERR + ABS(ZTOT(J) - ZTEST(J))/ZTOT(J)
            ZTEST(J) = ZTEST(J) *(1.0-RELAX)+ZTOT(J)*RELAX
            SERR = SERR + ABS(SEFFEST(J) - SEFF(J))
            SEFFEST(J) = SEFFEST(J)*(1.0-RELAX)+SEFF(J)*RELAX
            SMEAN  = SMEAN + ABS(SEFF(J))
 85       CONTINUE
          IF (SMEAN .GT. 1.E-10) SERR = SERR / SMEAN
        ENDIF
 80   CONTINUE
      ERROR2 = ZERR + BSERR + SERR
      IF(ERROR2 .GT. TOLER2) THEN
        IC = IC + 1
        IF(IC .GT. IZMAX) THEN
          WRITE(6,*)
          WRITE(6,*) ' ENTIRE SOLUTION REFUSES TO CONVERGE '
          WRITE(6,*)
          STOP
        ENDIF
        GOTO 800
      ENDIF
        FAST2 = FLOAT(IC-1) / FLOAT(IZMAX)
      DO 90 N = 1, NTOT
        EPEFF(N) = EPEFF(N) + DEFF(N)
        DO 90 K = 1, 3
          DEPOLD(K,N)    = DEP(K,N)
          DEP(K,N)    = 0.0
          EP(K,N)    = EP2(K,N)
 90   CONTINUE
 777  CONTINUE
      FAST = 5.0*(FAST1 + FAST2)
      RETURN
      END
C
C =====================================================================
C Deviats
C Compute deviatoric stress
C =====================================================================
C
      SUBROUTINE DEVIATS( J )
C
      IMPLICIT DOUBLE PRECISION ( A-H,O-Z )
C
```

```
      PARAMETER(NN=50)
      COMMON /STRES/  S(6,NN),  SDEV(6,NN),
     $                SEFF(NN), SE(NN), SEFFOLD(NN)
C
      SAVE = ( S(1,J) + S(2,J) + S(3,J) ) / 3.0
      DO 5 K = 1, 3
        SDEV(K,J) = S(K,J) - SAVE
 5    CONTINUE
      RETURN
      END
C =====================================================================
      FUNCTION CSEFF( J )
C
      IMPLICIT DOUBLE PRECISION ( A-H,O-Z )
C
      PARAMETER(NN=50)
      COMMON /STRES/  S(6,NN), SDEV(6,NN),
     $                SEFF(NN), SE(NN), SEFFOLD(NN)
C
      CSEFF = SQRT( 1.5*( SDEV(1,J)*SDEV(1,J) + SDEV(2,J)*SDEV(2,J)
     $  + SDEV(3,J)*SDEV(3,J) ) )
      RETURN
      END
C =====================================================================
C     Compute the effective stress with backstress
      FUNCTION CK2( J )
C
      IMPLICIT DOUBLE PRECISION ( A-H,O-Z )
C
      PARAMETER(NN=50)
      COMMON /MAT5B/  F3OLD(NN), BS(6,NN), SDEVOLD(6,NN)
      COMMON /STRES/  S(6,NN), SDEV(6,NN),
     $                SEFF(NN), SE(NN), SEFFOLD(NN)
C
      SUM = 0
      DO 5  K = 1, 3
        TERM = SDEV(K,J) - BS(K,J)
        SUM = SUM + TERM*TERM
 5    CONTINUE
      CK2 = SQRT(1.5*SUM)
      RETURN
      END
C =====================================================================
      FUNCTION CDEFF5( J )
C
```

```
      IMPLICIT DOUBLE PRECISION ( A-H,O-Z )
C
      PARAMETER(NN=50)
      COMMON /LOADT/  T, SZ, EZ, SR, TAU, DT,
     $                TINCR, SZINCR, EZINCR, SRINCR, DTAU,
     $                TIME, ICYCLE, IBLOCK
      COMMON /MAT5A /  TN(NN), TZ0(NN), TF1(NN), TF3(NN),
     $                TBSMAX(NN),  TD0(NN)
      COMMON /STRES/  S(6,NN),  SDEV(6,NN),
     $                SEFF(NN), SE(NN), SEFFOLD(NN)
C
      IF( SEFF(J) .LT. 1.E-22 )THEN
        CDEFF5  =0.0
      ELSE
        CDEFF5= TD0(J)*DEXP(-0.5*
     $    ( TZ0(J)/SEFF(J) )**(2*TN(J)) )*DTAU
      ENDIF
      RETURN
      END
C =====================================================================
      FUNCTION CDEFF6( J, ZTOT )
C
      IMPLICIT DOUBLE PRECISION ( A-H,O-Z )
C
      PARAMETER(NN=50)
      COMMON /LOADT/  T, SZ, EZ, SR, TAU, DT,
     $                TINCR, SZINCR, EZINCR, SRINCR, DTAU,
     $                TIME, ICYCLE, IBLOCK
      COMMON /MAT6A /  TND(NN), TZ0D(NN), TZ3(NN), TM2(NN),
     $                TA1(NN), TM1(NN), TZ1(NN), TR1(NN),
     $                TR2(NN), TD0D(NN), TZ2(NN),
     $                DTZ1(NN), DTZ2(NN), DTZ3(NN)
      COMMON /STRES/  S(6,NN),  SDEV(6,NN),
     $                SEFF(NN), SE(NN), SEFFOLD(NN)
      REAL*8             ZTOT(NN)
C
      IF( SEFF(J) .LE. 1.E-15 )THEN
        CDEFF6 = 0.0
      ELSE
        XTERM1 = (ZTOT(J) /SEFF(J))**2
        CDEFF6 = DEXP(-0.5*(XTERM1**TND(J)))
        CDEFF6 = TD0D(J)*CDEFF6*DTAU
      ENDIF
      RETURN
      END
```

```
C ======================================================================
      FUNCTION CDEFF( DEP, J )
C
      IMPLICIT DOUBLE PRECISION ( A-H,O-Z )
C
      PARAMETER( NN = 50)
      REAL*8             DEP(6,NN)
C
      SUM = 0.0
      DO 5 I = 1, 3
        SUM =  SUM + DEP(I,J)*DEP(I,J)
 5    CONTINUE
      CDEFF = SQRT( 2.0 * SUM /3.0)
      RETURN
      END
C ======================================================================
      FUNCTION YSURFACE( EPEST, J )
C
      IMPLICIT DOUBLE PRECISION ( A-H,O-Z )
C
      PARAMETER(NN=50)
      COMMON /STIF / IDAMAGE(10), D(NN), ETA(NN), SPEAK,
     $               DSM, DSCH, DSCL, DM, DTHETA, DDSTAR, DBETA, DDCH
      COMMON /ELASX/ TEO(NN),TE(NN),TNU(NN),TCTE(NN),ECOM,CTECOM
      COMMON /MAT2A / TSY(NN), TEP(NN)
C
      XM = TEP(J)/TE(J)
      XMO = TEP(J)/TEO(J)
      DSDE = XM*TE(J)/(1.0-XM)
      YSURFACE = DSDE*EPEST + TSY(J)*(1.0-XMO)/(1.0-XM)
      RETURN
      END
C ======================================================================
      FUNCTION YSURFACE2( J )
C
      IMPLICIT DOUBLE PRECISION ( A-H,O-Z )
C
      PARAMETER(NN=50)
      COMMON /STIF / IDAMAGE(10), D(NN), ETA(NN), SPEAK,
     $               DSM, DSCH, DSCL, DM, DTHETA, DDSTAR, DBETA, DDCH
      COMMON /ELASX/ TEO(NN),TE(NN),TNU(NN),TCTE(NN),ECOM,CTECOM
      COMMON /MAT2A /  TSY(NN), TEP(NN)
      COMMON /STRAI/  ETOT(6,NN), DEP(6,NN), EME(6,NN), ETH(NN),
     $                DEFF(NN), EPEFF(NN), DEPOLD(6,NN)
      COMMON /STRES/  S(6,NN),  SDEV(6,NN),
```

```
     $                SEFF(NN), SE(NN), SEFFOLD(NN)
      REAL*8               EMAX(NN)
C
CX    xm = tep(j)/te(j)
C     This is for 1-d case only. replace eme by the associated eeff.
      IF( EME(3,J) .GE. EMAX(J) ) EMAX(J) = EME(3,J)
      XMO = TEP(J)/TEO(J)
      YSURFACE2 = EMAX(J)*TEP(J) + TSY(J)*(1.0-XMO)
      RETURN
      END
C ======================================================================
C ********************************
C *  equation solver routines    *
C ********************************
C
C     For lower decomposition
C
C     Call ludcmp(a,n,n,indx,d)
C
C     For back substitution
C
C     Call lubksb(a,n,n,indx,b,x)
C     Note: solve for new x with b as old x
C
C ======================================================================
C  Ludcmp
C Compute lower decomposition of a matrix
C ======================================================================
C
      SUBROUTINE LUDCMP(A,N,NP,INDX,D)
C
      IMPLICIT DOUBLE PRECISION ( A-H,O-Z )
C
C     This subroutine provides du decomposition of its self
      PARAMETER  (NMAX=150, TINY=1.0E-20)
      DIMENSION A(NP,NP),INDX(NP),VV(NMAX)
C
      D = 1.
      DO 12 I = 1,N
        AAMAX = 0
        DO 11 J=1,N
          IF (ABS(A(I,J)) .GT. AAMAX) AAMAX = ABS(A(I,J))
 11     CONTINUE
        IF(AAMAX .EQ. 0) PAUSE 'SINGULAR MATRIX '
        VV(I) = 1./ AAMAX
```

```
 12   CONTINUE
      DO 19 J = 1,N
        DO 14 I=1,J-1
          SUM=A(I,J)
          DO 13 K = 1,I-1
            SUM=SUM-A(I,K)*A(K,J)
 13       CONTINUE
          A(I,J) = SUM
 14     CONTINUE
        AAMAX = 0.
        DO 16 I = J,N
          SUM=A(I,J)
          DO 15 K=1,J-1
            SUM = SUM-A(I,K)*A(K,J)
 15       CONTINUE
          A(I,J)=SUM
          DUM=VV(I)*ABS(SUM)
          IF(DUM .GE. AAMAX) THEN
            IMAX = I
            AAMAX =DUM
          ENDIF
 16     CONTINUE
        IF (J .NE.IMAX) THEN
          DO 17 K=1,N
            DUM=A(IMAX,K)
            A(IMAX,K)=A(J,K)
            A(J,K) = DUM
 17       CONTINUE
          D = -D
          VV(IMAX) = VV(J)
        ENDIF
        INDX(J)=IMAX
        IF(A(J,J) .EQ. 0. ) A(J,J) = TINY
        IF(J.NE.N) THEN
          DUM= 1./A(J,J)
          DO 18 I = J+1,N
            A(I,J)= A(I,J) *DUM
 18       CONTINUE
        ENDIF
 19   CONTINUE
      RETURN
      END
C
C =====================================================================
C  Lubksb
```

```
C Compute solves a*x=b
C =====================================================================
C
      SUBROUTINE LUBKSB (A,N,NP,INDX, B, X)
C
      IMPLICIT DOUBLE PRECISION ( A-H,O-Z )
C
C     This subroutine soves a set of n linear equations a*x = b
      DIMENSION A(NP,NP),INDX(NP), B(NP), X(NP)
C
      DO 3 IJ = 1, N
 3      X(IJ) = B(IJ)
      II = 0
      DO 12 I  =  1,N
        LL = INDX(I)
        SUM= X(LL)
        X(LL) = X(I)
        IF (II .NE. 0) THEN
          DO 11 J = II,I-1
            SUM = SUM - A(I,J)*X(J)
 11       CONTINUE
        ELSEIF (SUM .NE. 0) THEN
          II = I
        ENDIF
        X(I) = SUM
 12   CONTINUE
      DO 14 I=N,1,-1
        SUM = X(I)
        IF(I.LT.N) THEN
          DO 13 J=I+1,N
            SUM = SUM-A(I,J)*X(J)
 13       CONTINUE
        ENDIF
        X(I) = SUM/A(I,I)
 14   CONTINUE
      RETURN
      END
C
C =====================================================================
      CHARACTER*10 FUNCTION REAL10 ( VALUE )
C
      IMPLICIT REAL*8 (A-H,O-Z)
C     Write a floating-point value to a 10-character string
C
      CHARACTER*13 TEMP
```

```
C
C     First write value to temporary string temp in the form -x.xxxxxxe-nn
      WRITE (TEMP,'(1PE13.6)') VALUE
      REAL10 = '           '
C     Eliminate exponent field if possible
      IF ( TEMP(12:13) .EQ. '00' ) THEN
        REAL10(2:10) = TEMP(1:9)
        RETURN
      ENDIF
C     Write mantissa
      REAL10(1:8) = TEMP(1:8)
C     Write exponent sign (drop the 'e') and one- or two-digit exponent
      IF ( TEMP(12:12) .EQ. '0' ) THEN
        REAL10(9:9)   = TEMP(11:11)
        REAL10(10:10) = TEMP(13:13)
        REAL10(8:8) = 'E'
      ELSE
        REAL10(8:10)  = TEMP(11:13)
        REAL10(7:7) = 'E'
      ENDIF
      RETURN
      END
C
C =====================================================================
C |                                                                   |
C |                                                                   |
C |                                                                   |
C |                                                                   |
C |                                                                   |
C |   %%%%%%%%  %%%%%%%  %%%%%      %%%%%%%%  %%%%%%        %%%%     |
C |   %%%%%%%%  %%%%%%%  %%%%%%%    %%%%%%%%  %%%%%%%%    %%%%%%%%   |
C |   %%%         %%%    %%%  %%%   %%%       %%%   %%%  %%%    %%%   |
C |   %%%%%%      %%%    %%%   %%%  %%%%%%    %%%   %%%         %%%   |
C |   %%%%%%      %%%    %%%   %%%  %%%%%%    %%%%%%%%         %%%    |
C |   %%%         %%%    %%%   %%%  %%%       %%%%%%        %%%%     |
C |   %%%         %%%    %%%  %%%   %%%       %%%         %%%        |
C |   %%%       %%%%%%%  %%%%%%%    %%%%%%%%  %%%       %%%%%%%%    |
C |   %%%       %%%%%%%  %%%%%      %%%%%%%%  %%%       %%%%%%%%    |
C |                                                                   |
C |                                                                   |
C |                                                                   |
C |                                                                   |
C |                                                                   |
C =====================================================================
C End of File
```